UNIVERSITY OF TURKU

NURSING STUDENT–NURSE TEACHER COOPERATION USING MOBILE TECHNOLOGY DURING THE CLINICAL PRACTICUM

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To Tilda, Frida and Juice

ABSTRACT

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The purpose of this three-phase study was to describe the use of mobile devices in nursing student–nurse teacher cooperation during the clinical practicum, to develop a novel alternative called mobile cooperation intervention (MCI) for this cooperation and to evaluate its effectiveness on the students' clinical learning outcomes and acceptability from the perspective of nursing students. The ultimate goal is to improve the quality of nursing education and thus the outcomes of patient care.

In Phase I, an integrative review of use of the mobile devices in nursing student–nurse teacher cooperation during the clinical practicum was conducted. In Phase II, the CLES+T scale was further developed. Additionally, a mobile application called Study@CampusPro (App) and a mobile cooperation intervention (MCI) were developed. In Phase III, a randomised controlled trial design was used to evaluate the effectiveness of the MCI on nursing students' clinical learning outcomes, i.e. the individual outcomes (competence and self-efficacy) and contextual outcomes (quality of the clinical learning environment). Data were collected using three instruments (1) the Nurse Competence Scale (NCS), (2) the Self-efficacy in Clinical Performance instrument (SECP) and (3) the Clinical Learning Environment, Supervision and Nurse Teacher scale (CLES+T$_2$). Eligible nursing students (n=102) were randomly allocated to an intervention group (n=52) with mobile cooperation and a control group (n=50) with standard cooperation. The congruence between the nursing students' self-assessed competence and the mentors' assessments of the students' competence was examined by comparing the nursing students' self-assessments and their mentors' (n=95) assessments. Moreover, a process evaluation was conducted by examining the students' acceptability of the MCI by using a process evaluation questionnaire (Peq) developed for this study and the System Usability Scale (SUS) and student essays. The methods of analysis used in this study were critical appraisal, thematic and content analysis as well as descriptive statistics and statistical modelling.

There have been only a few studies (n=17) on nursing student–nurse teacher mobile cooperation and their methodological weaknesses are evident. The MCI was found to be significantly effective in facilitating nursing student–nurse teacher cooperation and as effective as standard cooperation in improving the clinical learning outcomes of nursing students. The older age was shown to be significantly associated with improvements in the competence in the whole study population. Students' self-assessed theoretical knowledge and practical skills prior to the clinical practicum were also shown to be significantly associated with the quality experienced of the clinical learning environment. In the control group, the students' self-assessed competence showed a weak but significant congruence with their mentors' assessments. The MCI was given a high degree of acceptance among students and the App's usability was rated as rather good. The items developed for the T -subscale of the CLES+T scale, on which the CLES+T$_2$ scale were based, demonstrated an appropriate level of content validity and good internal consistency.

This study suggests there is potential in the MCI to improve the quality of the nurse teacher's pedagogical cooperation with students and for being used as an alternative cooperation method in supporting students' clinical learning outcomes.

Keywords: clinical learning environment, clinical practicum, competence, cooperation, mobile application, nurse teacher, nursing student, self-efficacy

TIIVISTELMÄ

Camilla Strandell-Laine
HOITOTYÖN OPISKELIJAN JA OPETTAJAN VÄLINEN MOBIILITEKNOLOGIA-AVUSTEINEN OHJAUS HARJOITTELUN AIKANA
Turun yliopisto, Lääketieteellinen tiedekunta, Hoitotiede
Annales Universitatis Turkuensis, Turku, 2019

Tämän kolmivaiheisen tutkimuksen tarkoituksena oli kuvata mobiililaitteiden käyttöä opiskelijan ja opettajan välisessä harjoittelun aikaisessa ohjauksessa, kehittää mobiiliohjausinterventio (MCI) tähän ohjaukseen ja arvioida intervention vaikuttavuutta opiskelijan kliinisiin oppimistuloksiin ja intervention hyväksyttävyyttä opiskelijoiden näkökulmasta. Tutkimuksen tavoitteena on edistää hoitotyön koulutuksen laatua ja siten hoitotyön tuloksia.

Vaiheessa I tehtiin integratiivinen katsaus mobiililaitteiden käytöstä hoitotyön opiskelijan ja opettajan välisessä harjoittelun aikaisessa ohjauksessa. Vaiheessa II jatkokehitettiin kliininen oppimisympäristö, ohjaus ja opettaja (CLES+T) -mittaria sekä kehitettiin mobiiliapplikaatio Study@CampusPro (App) ja mobiiliohjausinterventio (MCI). Vaiheessa III toteutettiin satunnaistettu kontrolloitu tutkimus, jossa mitattiin mobiiliohjausintervention vaikuttavuutta hoitotyön opiskelijoiden kliinisiin oppimistuloksiin, yksilösidonnaisiin (kompetenssi ja minäpystyvyys) ja kontekstisidonnaisiin (kliinisen oppimisympäristön laatu) seuraavilla mittareilla: (1) Sairaanhoitajien ammattipätevyysmittari (NCS), (2) Self-efficacy in Clinical Performance (SECP) -mittari ja (3) CLES+T_2 -mittari. Tutkimukseen soveltuvat hoitotyön opiskelijat (n=102) satunnaistettiin mobiiliohjausta saavaan interventioryhmään (n=52) ja standardiohjausta saavaan kontrolliryhmään (n=50). Opiskelijoiden kompetenssin itsearviointien vastaavuutta ohjaajien arvioimaan opiskelijoiden kompetenssiin tarkasteltiin vertaamalla opiskelijoiden itsearviointeja ohjaajien (n=95) arviointeihin. Lisäksi toteutettiin prosessievaluaatio, jossa selvitettiin opiskelijoiden mobiiliohjausintervention hyväksyttävyyttä tätä tutkimusta varten kehitetyllä prosessievaluaatiokyselyllä (Peq), SUS -mittarilla ja opiskelijoiden esseillä. Analyysimenetelminä olivat kriittinen arviointi, temaattinen ja sisällön analyysi sekä kuvailevat tilastolliset menetelmät ja tilastollinen mallintaminen.

Mobiililaitteiden käytöstä hoitotyön opiskelijan ja opettajan välisessä harjoittelun aikaisessa ohjauksessa on rajoitetusti aikaisempia tutkimuksia (n=17) ja niissä on havaittavissa menetelmällisiä heikkouksia. Mobiiliohjausinterventio osoittautui tehokkaaksi menetelmäksi hoitotyön opiskelijan ja opettajan välisessä harjoittelun aikaisessa ohjauksessa sekä yhtä tehokkaaksi edistämään opiskelijoiden kliinisiä oppimistuloksia kuin standardiohjaus. Opiskelijan korkeammalla iällä ja kompetenssin kasvulla oli merkitsevä yhteys koko tutkimuspopulaatiossa. Opiskelijoiden itsearvioimilla teoreettisilla tiedoilla ja käytännön taidoilla ennen harjoittelua sekä koetulla kliinisen oppimisympäristön laadulla oli merkitsevä yhteys. Kontrolliryhmässä oli heikko vastaavuus opiskelijoiden ja ohjaajien arvioiman opiskelijoiden kompetenssin välillä. Mobiiliohjausinterventio oli erittäin hyväksyttävä ja mobiiliapplikaation käytettävyys oli melko hyvä opiskelijoiden arvioimana. CLES+T -mittariin kehitetyt uudet T_2 -osion väittämät, jotka olivat perustana CLES+T_2 -mittarille, olivat sisällöllisesti valideja ja johdonmukaisia.

Tämä tutkimus osoittaa mobiiliohjausinterventiolla olevan potentiaalia edistää hoitotyön opettajan pedagogisen ohjauksen laatua ja se soveltuu vaihtoehtoiseksi ohjausmenetelmäksi tukemaan opiskelijan kliinisiä oppimistuloksia.

Avainsanat: ammattitaitoa edistävä harjoittelu, hoitotyön opettaja, hoitotyön opiskelija, kliininen oppimisympäristö, kompetenssi, minäpystyvyys, mobiiliapplikaatio, ohjaus

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LIST OF ABBREVIATIONS

App	Study@Campus[Pro] web mobile application
ARENE	Rectors' Conference of Finnish Universities of Applied Sciences
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CLE	Clinical learning environment
CG	Control group
CONSORT	Consolidated Standards of Reporting Trials
EC	European Commission
ECTS	European Credit Transfer and Accumulation System
EFN	European Federation on Nurses
EQF	European Qualifications Framework
ERIC	Education Resources Information Center
EU	European Union
GNS	Graduated nursing student
HEI	Higher education institution
ICT	Information and communication technology
IG	Intervention group
ICN	International Council of Nurses
MADLC	Mobile Application Development Lifecycle Model
MCI	Mobile cooperation intervention
MEDLINE	Medical Literature Analysis and Retrieval System Online
MRC	The Medical Research Council
NS	Nursing student
NT	Nurse teacher
RCT	Randomized controlled trial
RN	Registered nurse
SAS	Statistical Analysis System
SD	Standard deviation
SPIRIT	Standard Protocol Items: Recommendations for Interventional Trials
SPSS	Statistical Package for the Social Sciences
TIDieR	Template for intervention description and replication
Q_1	Lower quartiles
Q_3	Upper quartiles
UAS	University of applied sciences
VAS	Visual analogue scale
WHO	World Health Organization

LIST OF ORIGINAL PUBLICATIONS

This doctoral thesis is based on the following original publications referred to in the text by the Roman numerals I–IV.

I Strandell-Laine C, Stolt M, Leino-Kilpi H & Saarikoski M. 2015. Use of mobile devices in nursing student–nurse teacher cooperation during the clinical practicum: An integrative review. Nurse Education Today 35(3), 493–499.

II Strandell-Laine C, Saarikoski M, Löyttyniemi E, Salminen L, Suomi R & Leino-Kilpi H. 2017. Effectiveness of a mobile cooperation intervention during the clinical practicum of nursing students: a parallel group randomized controlled trial protocol. Journal of Advanced Nursing 73(6), 1502–1514.

III Strandell-Laine C, Saarikoski M, Löyttyniemi E, Meretoja R, Salminen L & Leino-Kilpi H. 2018. Effectiveness of the mobile cooperation intervention on students' clinical learning outcomes: A randomized controlled trial. Journal of Advanced Nursing 74(6), 1319–1331.

IV Strandell-Laine C, Leino-Kilpi H, Löyttyniemi E, Salminen L, Stolt M, Suomi R & Saarikoski M. A process evaluation of a mobile cooperation intervention: A mixed methods study. (Submitted)

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1   INTRODUCTION

Nursing education is an important component in society due to the tasks involved in developing nursing as a profession and for generating a nursing workforce of sufficient competence to provide safe and high-quality patient care (Aiken et al. 2014). In Europe there are roughly six million nurses, the largest professional group in the healthcare sector (Sermeus et al. 2011, Eurostat 2018, WHO, World Health Organization 2018). Regarding nursing students in Europe, about 190 000 graduated in 2016 (Eurostat 2018), of which 3100 were from Finland (Ministry of Education and Culture 2017a) while approximately 4200 started their nursing degree studies in Finland (Ministry of Education and Culture 2017b). Nevertheless, the European healthcare sector is facing decreases in the nursing workforce and a shortage of healthcare professionals (EC, European Commission 2011, Sermeus et al. 2011, EC 2012, WHO 2018), which is inherently due to the retirement of an aging nursing workforce (Girot & Albarran 2012, Duffield et al. 2015, Sulander et al. 2016) and the high rate of intention to leave the nursing profession (Aiken et al. 2012), but even higher among young nurses in Finland (Flinkman 2015), which is up to 49% (Aiken et al. 2012).

Nursing education needs to respond, by transforming education, not only to cope with the predicted shortfalls in the nursing workforce but also to a rapidly developing labour market (ARENE 2016) with increasingly complex practices in nursing (WHO 2009, Salminen et al. 2010, EC 2012, Willis Commission 2012, Flott & Linden 2016, Missen et al. 2016a, 2016b, Lee et al. 2018a). Furthermore, nursing faces challenges in people-centred care (WHO 2013) due to the changing socio-demographics of patients and healthcare service users as well as the rapidly evolving area of health technology that provides digital solutions for health and care (EC 2018a). All these factors are changing the competencies nurses require in order to succeed in the nursing profession. In addition, the changing role of nursing is creating challenges for the development and delivery of curricula in nursing education. Moreover, a major national reform called SOTE reform, of the social welfare and healthcare systems which has been in preparation in Finland for years, may result in additional challenges to the development of a future nursing workforce for integrated social welfare and healthcare services (National Institute for Health and Welfare 2018).

The directives 2005/36/EC and 2013/55/EU as well as the European Qualifications Framework, EQF (EC 2008) regulate nursing students' degree studies (a minimum of 180 European Credit Transfer and Accumulation System [ECTS] credits), consisting of theoretical and clinical training. Commonly, the theoretical training is conducted in educational institutions while the clinical training (a minimum of

90 ECTS credits) – also called a clinical practicum – is conducted in a clinical practice setting (Directive 2005/36/EC, Directive 2013/55/EU, Needham et al. 2016). The aim of the clinical practicum is to facilitate nursing students' learning and professional development (Cooper et al. 2015) through interaction with a healthy or sick individual and/or community, nurses and other professionals in the clinical practice (Directive 2005/36/EC). Thus, the clinical practicum is an essential part of nursing degree studies (e.g. Price et al. 2011, Henderson et al. 2012, Cooper et al. 2015, Rowbothman & Owen 2015, Saarikoski 2018), where nursing students gain unique first-hand experiences of patient care (Flott & Linden 2016, Kim & Suh 2018) in various learning situations (Salminen et al. 2010, Henderson et al. 2012, Killam & Heerschap 2013, Rowbotham & Owen 2015, Flott & Linden 2016) and which cannot be experienced through theoretical studies (Kim & Suh 2018).

Nursing students' clinical practicum hours have constantly decreased throughout Europe (Hall-Lord et al. 2013, Mikkonen et al. 2017a). Therefore, the time spent in a clinical practice becomes even more crucial (Chan 2002, Warne et al. 2010, Price et al. 2011, Henderson et al. 2012, Suikkala et al. 2018) in preparing them to meet the challenges of a future nursing workforce. However, it seems that this complex nursing practice and its competence demands (Salminen et al. 2010, Willis Commission 2012, Missen et al. 2016a, 2016b) have not fully been taken into consideration in the nursing curricula (Flott & Linden 2016, Lee et al. 2018a), which relies on students' self-directed learning (Knowles 1975, Cadorin et al. 2017, Voutilainen et al. 2017, Kim & Suh 2018) and constructivist teaching methods which are focusing on the subjective experiences of the nursing students (Aliakbari et al. 2015). Nursing professionals concerns about the risk of patient safety due to the inadequate competences of graduated nursing students (GNSs) have been reported in previous studies (e.g. Clark & Holmes 2007, Lakanmaa 2012, Flott & Linden 2016, Missen et al. 2016a, 2016b). Nevertheless, the competences of GNSs have been reported as good (Wangensteen et al. 2012, Kajander-Unkuri et al. 2014, Meretoja et al. 2015, Gardulf et al. 2016, Theander et al. 2016, Numminen et al. 2017) or rather good when assessed by themselves (Räisänen 2002, Salmela 2004, Lima et al. 2016) and by nurse teachers (Räisänen 2002, Salmela 2004, Numminen et al. 2014), whereas nursing professionals report lower levels of GNS competence (Salmela 2004, Numminen et al. 2014). Only limited amount of evidence exists about the level of competence of nursing students during their studies (Löfmark et al. 2006, Kajander-Unkuri et al. 2014, 2015). Thus, there is a need for robust evidence of nursing students' clinical learning outcomes – especially with regard to competence, in order to guide policy decision-making, nursing curricula development and decision making during clinical practice and thus ultimately benefiting the outcomes of patient care.

In Finland, since the beginning of the higher education institution (HEI) reform that began in the 1990s, Saarikoski (2002) and Saarikoski et al. (2002, 2008, 2009a, 2009b, 2013) have conducted several studies focusing on the quality of the clinical learning environment and nursing student supervision in the clinical practicum Moreover, international research cooperation has been multidimensional in this specific field (e.g. Johansson et al. 2010, Papastavrou et al. 2010, Warne et al. 2010, Tomietto et al. 2012, 2016, Papastavrou 2016a), resulting in study findings that nursing students are commonly satisfied with the clinical learning environment and the supervision they receive in the practicum ward. However, decreases in the nurse teachers' resources for clinical visits during the nursing students' clinical practicum have become a trend in Europe. These resources have decreased also in Finland (Saarikoski et al. 2008, 2009a, 2009b, 2013, ARENE 2016, Helminen et al. 2017, Mikkonen et al. 2017a, Pitkänen et al. 2018) – mainly due to the governmental cuts for the higher education (ARENE 2016) and the new principle of performance-based funding for the universities of applied sciences (UAS) (Government Decree on UASs 1129/2014). However, in Finland, the nurse teachers' clinical role in student supervision is increasingly conducted at UASs by means of distance nursing student–nurse teacher cooperation methods (Saarikoski et al. 2009b, 2013, Mikkonen 2017a). Thus, it is important to develop effective novel alternatives to facilitate nursing student–nurse teacher cooperation and thus achieve the desired clinical learning outcomes for nursing students. One possible solution is the integration of mobile technology (Saarikoski et al. 2009b, 2013, Willemse 2015, MacKay et al. 2017).

In Europe (EC 2014, 2018b) and Finland (Junger 2016, Parviainen et al. 2017) recommendations have been presented for transforming higher education through the integration of mobile technology into education. These recommendations ought to be more highly recognised in nursing curricula and instruction. The use of information and communication technology (ICT) is not new in nursing education (Yucha & Regeluth 1983, Saranto & Leino-Kilpi 1997). Currently, various mobile technology solutions are available to provide new tools and methods for teachers and students. However, the integration of mobile technology into nursing education (Beauregard et al. 2017, EC 2018b, Lee et al. 2018b) remains limited. In Finland, the outcomes of learning and teaching ICT in nursing education were evaluated at an early stage of HEI reform in late 1990s by Saranto (1997). However, the recent systematic review by Voutilainen et al. (2017) reveals that the effect of ICT on nursing students' learning outcomes remains unclear. Furthermore, the integration of mobile technology into the nursing curricula, especially in the clinical practicum, seems to be a slowly evolving area in Finland (Mettiäinen & Karjalainen 2011, Mettiäinen 2015). This trend is also international

and can be seen in reviews of the integration of mobile technology into the clinical practicum (Ward & Moule 2007, Zurmehly 2010, Doyle et al. 2014, Guo et al. 2015, O'Connor & Edwards 2015, Raman 2015, Strandell-Laine et al. 2015, [Paper I]). Therefore, there is need to develop novel alternatives that utilise the possibilities of mobile technology and which evaluate their effectiveness in facilitating nursing student–nurse teacher cooperation. Thus, it may be possible to respond to even complex clinical practice demands and to maintain the best possible clinical learning outcomes for nursing students and to respond to the changed clinical role of the nurse teacher and the increased use of digital technology in society.

In this study, the focus is on mobile technology-enhanced nursing student–nurse teacher cooperation. The purpose of this three-phase study was to describe the use of mobile devices in nursing student–nurse teacher cooperation during the clinical practicum, to develop a novel alternative, i.e. mobile cooperation intervention (MCI), for nursing student–nurse teacher cooperation during the clinical practicum and to evaluate its effectiveness on nursing students' clinical learning outcomes and acceptability from the perspective of nursing students. The ultimate goal is to improve the quality of nursing education and consequently the outcomes of patient care. While nursing students are the end-users of nursing education, their needs and experiences of the delivery of that education needs be acknowledged on their journey to becoming part of a new nursing workforce, which is why this study has strong student involvement and examines the students' point of view.

The study was carried out in Finland between 2013 to 2018 and is located in the field of nursing education research because it focuses on the cooperation between nursing students and nurse teachers in the context of the clinical learning environment (Hentinen 1989). In addition, this study focuses on the nursing students' clinical learning outcomes, which are crucial for the delivery of safe and high-quality patient care (Aiken et al. 2011, 2014). The evidence provided in this study enables reflection on the use of mobile technology in the cooperation between nursing students and nurse teachers and its impact on the clinical learning outcomes of nursing students. This study produces new evidence about the effectiveness and acceptability of MCI in the context of the clinical practicum, which represents the essential component of nursing education. Thus far only a few studies have been undertaken on this subject and they have not been in-depth (Raman 2015, Strandell-Laine et al. 2015).

2   DEFINITION OF THE CONCEPTS

In this chapter, the main concepts used in this study *clinical practicum, nursing student*, *nurse teacher*, *mobile technology*, *mobile device, mobile application, nursing student–nurse teacher mobile cooperation* and *clinical learning outcomes,* are defined. The definitions are based on the current legislation, European Union Directives (Directive 2005/36/EC, Directive 2013/55/EU) and previous studies.

Clinical practicum

The clinical practicum should facilitate the learning and professional development of nursing students (Cooper et al. 2015, Järvinen et al. 2018) by providing them with opportunities to integrate their theoretical knowledge into practice (Wu 2014b, Rowbotham & Owen 2015, Flott & Linden 2016, Forber et al. 2016), to develop and learn clinical skills (Wu 2014b, Forber et al. 2016, Doyle et al. 2017, Lee et al. 2018a, Pitkänen et al. 2018) and to develop their professional identity and attitudes (McNamara 2015, Forber et al. 2016) at the bedside and direct contact with patients (Directive 2013/55/EU).

The length and quantity of the clinical practicum periods varies in nursing curricula across Europe (Warne et al. 2010, Lahtinen et al. 2014), but students share the same requirements to conduct at least 90 ECTS credits or 2300 clinical practicum hours (Directive 2005/36/EC, Directive 2013/55/EU) of their professional nursing studies (180 ECTS credits) in the clinical practice. Furthermore, appropriate knowledge, skills and the eight competences stated in Directive 2013/36/EU should be achieved during nursing degree studies (Directive 2013/55/EU). The clinical practicum has to be delivered across various clinical environments: healthcare organisations, hospitals and other healthcare institutions and in the community in authentic patient care situations (Directive 2013/55/EU). In addition, the Directive 2013/55/EU and its Annex V.2 state that the clinical practicum should be implemented in the context of general and specialist medicine, general and specialist surgery, child care and paediatrics, maternity care, mental healthcare and psychiatry, the care of the old and geriatrics and home nursing. However, students are usually placed in the same clinical context throughout their single practicum period (Warne et al. 2010, Löfmark & Thorell-Ekstrand 2014).

In Finland, the clinical practicum consists of the clinical practicum conducted at a clinical practice as well as classroom (skill labs) and/or simulation centre exercises with simulated patients or with high-fidelity mannequins as alternatives to direct patient contact (75 ECTS credits). However, nursing students still spent most of their clinical practicum hours in a clinical practice. Additionally, 15 ECTS credits for doing a bachelor's thesis are generally counted as clinical practicum credits in

Finnish nursing curricula. (Eriksson et al. 2015.) While the delivery of education is governed by the specific degree regulations of UAS (UAS Act 932/2014), the annual nursing curricula, the forms of the instruction and the content of the nursing degree studies and also the delivery of the clinical practicum may vary between UASs in Finland (Eriksson et al. 2015, Finnish National Agency for Education 2017).

In this study, *clinical practicum* refers to nursing students' clinical training as defined in European Union Directive 2005/36/EC and Directive 2013/55/EU and it is conducted in the clinical practice, in-patient or out-patient hospital wards in direct contact with patients while under the supervision of mentor(s) from the clinical practice and nurse teacher from the HEI (Lauder et al. 2008b, Saarikoski et al. 2009b, Warne et al. 2010, Löfmark et al. 2012, Directive 2005/36/EC, Hall-Lord et al. 2013, Salminen et al. 2013, Needham et al. 2016). In the Finnish Government Decree on UASs (1129/2014) the clinical practicum is defined in Finnish as '*ammattitaitoa edistävä harjoittelu*' and in the UAS Act 932/2014 in English as '*practical training*'. The supervision of nursing students in the clinical practicum is described in more detail in Chapter 3.1.

Nursing student

In Europe, the completion of nursing degree studies leads to the formal qualification of a nurse responsible for general care (Directive 2005/36/EC, Annex V.2). In this study, nursing degree studies refers to a *bachelor's degree level nursing education*. The minimum requirement of the length and content of nursing degree studies is 3 years or 180 ECTS credits in Europe (Directive 2005/36/EC, Directive 2013/55/EU), where one ECTS credit stands for 27 hours of nursing student work. In Finland, the Directive 2005/36/EC is implemented to the higher requirement of 210 ECTS credits to be completed before graduation.

In Europe, nursing students conduct their degree studies, in various educational institutions, at universities, colleges and UASs (Saarikoski et al. 2013, Lahtinen et al. 2014), mainly on the higher-education-level but also on diploma-level (WHO 2009, Willis Commission 2012, Lahtinen et al. 2014). In Finland, since the 1990s, nursing education is delivered in HEIs by UASs (Salminen 2001, Salminen et al. 2010). In 2018, nursing education was delivered in Finland in 22 UASs, of which 21 operated as public limited liability companies (Ministry of Education and Culture 2017c) and had operating licenses granted by Finland's Government (UAS Act 932/2014); Åland's UAS operated under the mandate of the Ministry of the Interior (Ministry of Education and Culture 2017c).

In Finland, a nursing student graduating from a degree programme in nursing will qualify as a registered nurse (RN) [suom. sairaanhoitaja (AMK), Bachelor in

Health Care]. For full-time students, nursing degree studies will commonly be completed in 3.5 years comprising seven semesters in Finland. The completion of the degree programme in public health nursing (240 ECTS credits), midwifery (270 ECTS credits) and emergency care (240 ECTS credits) also includes the RN's qualification. (UAS Act 932/2014, Government Decree on UASs 1129/2014.)

In Finland, neither tuition fees (UAS Act 932/2014) nor licensure exams exist for nursing students and their fitness for nursing practice are evaluated mainly by their professional performance during the clinical practicum. After completing the degree studies, the right to practice as a licensed healthcare professional (registered nurse, midwife, public health nurse or emergency nurse) is granted upon application, without specific requirements, by the National Supervisory Authority for Welfare and Health (Valvira), the former National Authority for Medicolegal Affairs (Health Care Professionals Act 559/1994). In this study, *nursing student* refers to a second-year bachelor's degree level nursing student, who is studying in a degree programme of nursing, midwifery or public health nursing in the UAS, conducting either a second or third clinical practicum and whose completed degree studies will lead to the formal qualification of a nurse responsible for general care (Directive 2005/36/EC, Annex V.2).

Nurse teacher

Nurse teachers have a key role in nursing education but their education and qualification requirements (Salminen et al. 2010) as well as career pathways (Jackson et al. 2009) differ extensively across Europe. There is no common consensus on the minimum qualification or required competences of a nurse teacher (Salminen et al. 2010, 2013), but a qualification at the doctoral-level is seen as desirable for nurse teachers as it provides the basis for future research leaders in nursing (Jackson et al. 2009, Booth et al. 2016). In Australia and the United Kingdom, the primary qualification criteria for nurse teachers is clinical expertise and the attainment of a teaching diploma (Jackson et al. 2011).

In Finland, there are principal lecturers, lecturers or other teaching staff working in UASs (UAS Act 932/2014). The degree requirement for a principal lecturer [suom. yliopettaja] is the appropriate licentiate or doctoral degree and for a lecturer [suom. lehtori] an appropriate higher education degree. In addition, principal lecturer and lecturer is required to have pedagogical studies and competence. A person without an appropriate degree, can be deemed by the UAS to have sufficient knowledge and skills for implementing teaching. Teaching professional study modules, such as a clinical practicum, requires at least three years' working experience in the clinical area that corresponds to the degree. (Government Decree on UASs 1129/2014.) In 2010 in Finland, about 10% of nurse teachers had a doctoral degree (Salminen et al. 2010).

Finnish nurse teachers (principal lecturers, lecturers or other teaching staff) carry out the teaching of theoretical studies conducted in the UASs and also have a clinical role when they supervise students during the clinical practicum (Directive 2005/36/EC, Annex V.2, Saarikoski et al. 2009b, Salminen et al. 2013). However, the clinical role of the nurse teachers varies across UASs in Finland. In this study, the focus is on the nurse teacher's clinical role. In this study, *nurse teacher* refers to an educationally certified, holding an Academic degree, who is employed by a HEI and holds the main responsibility for the education of nursing students during a clinical practicum (Directive 2005/36/EU).

Mobile technology

The concept of mobile technology is commonly used in recent nursing education literature (Doyle et al. 2014, Guo et al. 2015, O'Connor & Andrews 2015, Raman 2015, Strandell-Laine et al. 2015, Forehand et al. 2017) although there is no common definition (O'Connor & Andrews 2015, Forehand et al. 2017, Mackay et al. 2017) and rationale for its use (O'Connor & Andrews 2015). However, the use of mobile technology has become commonplace for communication among today's nursing students (Montenery 2013, Litchfield et al. 2016, Beauregard et al. 2017, Forehand et al. 2017, Roberts & Williams 2017), representing both millennials (Montenery et al. 2013, Litchfield el. 2016) and generation Y (born after 1982).

Mobile technology has created a wireless society that enables social connectivity (Forehand et al. 2017) and additional support and knowledge acquisition (Wyatt et al. 2010). Thus, it is argued that mobile technology has the potential to enhance (Forehand et al. 2017) and revolutionise teaching and learning methods (Grady 2011, Mackay et al. 2017) by creating an abundance of new innovative opportunities that can be utilised in the classroom and in clinical learning environments (Wyatt et al. 2010, Mann et al. 2015, Colton & Hunt 2016, Litchfield et al. 2016). However, the benefits of mobile technology use are not fully utilised in nursing education (Strandell-Laine et al. 2015, Roberts & Williams 2017). In this study, *mobile technology* refers to mobile devices, particularly smartphones and tablet computers with built-in application features and Internet access (Doswell et al. 2013).

Mobile device

Mobile devices, such as smartphones, tablet computers, watches, portable computers, combine computing and communication features in a small hands-on device, enabling flexibility in information retrieval (Mosa et al. 2012, Airth-Kindree & Vandenbark 2014, Hay et al. 2017) and use independent of location (Zayim & Ozel 2015). Mobile devices are equipped with built-in application

features and wireless access to the Internet (Doswell et al. 2013) and can be used to support learning (George et al. 2016) in a way that is not otherwise possible (Maneval & Mechtel 2017).

In Finland, mobile device penetration among the student population is very high, 98% of Finnish students own a mobile phone (Suominen et al. 2014, Statistics Finland 2017). In addition, in 2017, half of the 16–89-year-old Finns lived in a household that uses a tablet computer (Statistics Finland 2017). Mobile devices are increasingly ubiquitous in nursing practice (Gambo et al. 2017) and therefore also integral to nursing education. In this study, a *mobile device* refers to smartphones and tablet computers.

Mobile application

A mobile application, commonly called an app, is software designed to run on a mobile device. Mobile applications are essential for mobile device utilization. (Doswell et al. 2013.) These applications are either downloadable from the Internet (web mobile applications), or from application stores for a fee or even free of cost (single mobile applications) (Mosa et al. 2012).

Mobile applications have been successfully used to facilitate nursing students' information and time management, communication, information gathering, patient management and clinical decision-making (Mosa et al. 2012). In this study, *App* refers to the web mobile application called Study@Campus[Pro], which was developed for this study as a module within a broader system that can be used to facilitate nursing student–nurse teacher cooperation during the clinical practicum.

Nursing student–nurse teacher mobile cooperation

The supervision of nursing students during their clinical practicum is traditionally conducted through cooperation between the nurse teacher from the educational institution and the mentor from the clinical practice (Lauder et al. 2008b, Saarikoski et al. 2009b, Löfmark et al. 2012, Hall-Lord et al. 2013, Needham et al. 2016). In this study, the term *nursing student–nurse teacher cooperation* is used to refer to the pedagogical activities in the relationship between student and teacher, i.e. student supervision conducted by the nurse teacher in the context of the clinical practicum, which is what this study focuses on.

The aim of the nursing student–nurse teacher cooperation is to support nursing students in the integration of theory and practice (Löfmark et al. 2012) and to support students' professional development during the clinical practicum (Mackay & Harding 2009, Saarikoski 2009b, Löfmark et al. 2012). In this study, *nursing student–nurse teacher mobile cooperation* refers to the use of mobile devices and

the App for (1) the documentation of the schedule of the clinical practicum shifts, the learning objectives, the learning diary, and the mid-point and final evaluations; and (2) for individual or group support and communication between student(s) and teacher during the clinical practicum. In this study, the focus is on novel distance cooperation methods that use mobile technologies, i.e. mobile devices and applications and without the nurse teacher visiting practicum wards.
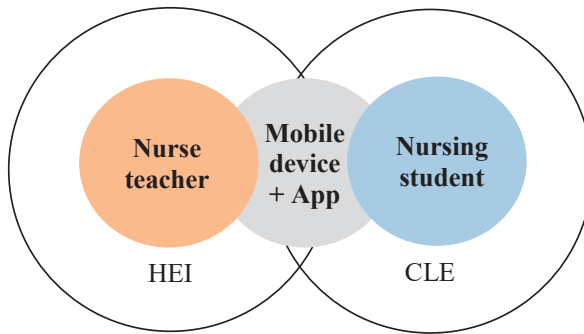
Figure 1. Nursing student–nurse teacher mobile cooperation.
HEI = higher education institution; CLE = clinical learning environment

Clinical learning outcomes

Clinical learning outcomes are the nursing student's learning outcomes which are attained during the clinical practicum that is conducted at a clinical practice while in direct contact with patients. In this study, *clinical learning outcomes* comprise individual and contextual outcomes. *Individual outcomes* refers to the competence (WHO 2006, Nursing and Midwifery Council 2010, EC 2013, European Federation of Nurses 2015) and self-efficacy (Lauder et al. 2008b, Chesser-Smyth & Long 2013) of nursing students, stated as the main expected learning outcomes of nursing education (Lauder et al. 2008b). Furthermore, in this study, the *contextual outcomes* refer to the quality experienced of the clinical learning environment (CLE) in which the clinical practicum for the respective nursing students occurs. Saarikoski et al. (2008) define the core components for a high quality clinical learning environment as being comprised of a clinical learning environment, a supervisory relationship with the mentor and the role of the nurse teacher, which is the definition used in this study; the focus is on the role of nurse teachers, especially in the nursing student–nurse teacher cooperation. The concepts of competence, self-efficacy and the quality of the clinical learning environment are described in more detail in Chapter 3.2.

Table 1. Summary of the definitions of the main concepts used in this study.

Main concept	Definition
Clinical practicum	Nursing students' clinical training as defined in the European Union Directive 2005/36/EC and Directive 2013/55/EU, aiming to improve clinical learning outcomes.
Nursing student	A second-year bachelor's level nursing student from the UAS conducting their clinical practicum, whose completed degree studies will lead to a formal qualification of a nurse responsible for general care (Directive 2005/36/EC, Annex V.2).
Nurse teacher	An educationally certified teacher employed by an HEI, who has the main responsibility for the nursing students' education during the clinical practicum (Directive 2005/36/EC).
Mobile technology	Mobile devices, e.g. smartphones and tablet computers, with built-in application features and Internet access (Doswell et al. 2013).
Mobile device	Smartphones and tablet computers.
App	A web mobile application (Study@Campus[Pro]), developed as a module for a wider system for this study in order to facilitate nursing student–nurse teacher cooperation during the clinical practicum.
Nursing student–nurse teacher mobile cooperation	The supervision procedures between a nursing student and nurse teacher during the clinical practicum based on the nurse teacher's responsibilities for supporting nursing students during the clinical practicum (Directive 2005/36/EC); conducted by distance cooperation methods with the aid of mobile technology, i.e. the mobile device and the App.
Clinical learning outcomes	The individual and contextual outcomes which are reached regarding the nursing students' clinical practicum conducted at a clinical practice when they are in direct contact with patients as defined in the European Union Directives 2005/36/EC and 2013/55/EU. • Individual outcomes refers to the nursing students' competence (WHO 2006, NMC 2010, EC 2013, EFN 2015) and self-efficacy (Lauder et al. 2008b, Chesser-Smyth & Long 2013), stated as the main expected learning outcomes of nursing education. • Contextual outcomes refers to the quality of the clinical learning environment as experienced by the nursing students – in which the nursing students' clinical practicum occurs as defined in the European Union Directives 2005/36/EC and 2013/55/EU.

3   LITERATURE REVIEW

In Finland, previous nursing education studies have focused on four main areas: structural factors in education, nurse teacherhood, teaching activities, and learning and learning outcomes in nursing education (Salminen et al. 2006, Vierula et al. 2016). There are studies focusing on nursing students' clinical learning, clinical learning environments and clinical skills with various perspectives, such as the student–patient relationship (Suikkala 2007), ethical problems (Brunou 2009), the quality of the clinical learning environment (Saarikoski 2002, Mikkonen 2017) and supervision (Saarikoski 2002, Luojus 2011, Jokelainen 2013, Helminen 2017, Mikkonen 2017) as well as student competence (Kajander-Unkuri 2016). However, the need for further experimental study designs in nursing education studies (Hentinen 1989, Salminen et al. 2006, Vierula et al 2016) and studies focusing on nursing student–nurse teacher cooperation are presented (Hentinen 1989, Vierula et al. 2016).

The studies included in this review are organised around three key themes. First, the supervision of nursing students in the clinical practicum is described according to the current legislation, the EU directives, existing literature and previous studies.

Second, the nursing students' clinical learning outcomes are described based on the existing literature and previous studies. The aim of these reviews was to gain an understanding of the regulatory and theoretical background of this study.

Third, the nursing student–nurse teacher mobile cooperation is described with reference to previous studies. The aim of this review is to gain a comprehensive understanding of mobile device use in nursing student–nurse teacher cooperation in the clinical practicum, in particular, how they have been used and for what purposes, thus constructing the evidence base (Figure 3, Page 47) for the empirical study.

Literature search

The literature search for the first and second part of the literature review was conducted using the same search terms across four electronic databases PubMed/Medline, CINAHL, PsycINFO and ERIC. The search terms relate to nursing students' competence, self-efficacy and the quality of the clinical learning environment as experienced by the nursing students. Search terms were used in different combinations to find relevant references (Table 2). The searches were limited to publications from 2000 to 2018, which covers the time period of the Bologna agreement (European Ministers of Education 1999) and the EU directives (2005/36/EC, 2013/55/EU) as they have had an essential impact on the

development of European nursing education (Jokelainen et al. 2011b). Database searches were complemented by manual searches in the reference lists of the article to identify more relevant references. In addition, searches were conducted by using general web search engines to identify relevant references using the same search terms as in the database searches. The literature search for the third part of the literature review is described in Chapter 3.3.

Table 2. Search terms used in the database searches.

Concept	Search terms
Competence	competenc*, professional competence, clinical competence
Self-efficacy	self-efficacy
Nursing student	student*, nurse, nursing
Clinical practicum	practice, clinical, placement*
Clinical learning environment	clinical learning environment, learning environment
Nurse teacher	teacher*, tutor*, instructor*, facilitator*, lecturer*, educator*
Mentor	mentor, preceptor, facilitator, supervisor

3.1 Nursing student–nurse teacher cooperation during the clinical practicum

The supervision of nursing students in the clinical practicum

In Europe and also in Finland, nursing students have conducted their clinical practicum under the supervision of a mentor from the clinical practices and nurse teachers from the HEI (Directive 2005/36/EC, Lauder et al. 2008b, Saarikoski et al. 2009b, Warne et al. 2010, Löfmark et al. 2012, Hall-Lord et al. 2013, Salminen et al. 2013, Needham et al. 2016).

The main responsibility for this supervision falls on the nurse teacher (Directive 2005/36/EC, Lauder et al. 2008b, Hall-Lord et al. 2013, Salminen et al. 2013). However, according to Directive 2013/55/EU, each nursing student conducting a clinical practicum at a clinical practice should be assigned to a RN working at the clinical practice. Mentors can be defined as professional role models who support nursing students in their professional development (Saarikoski et al. 2007, 2009b, Levett-Jones et al. 2009, Jokelainen et al. 2011b, Manninen et al. 2015). Mentor supervision includes daily face-to-face student supervision and support regarding the clinical skills used on the wards throughout the entire clinical practicum (Lauder et al. 2008b, Directive 2013/55/EU, Hall-Lord et al. 2013). In this study,

mentor refers to the assigned RN from the nursing students' practicum ward, who has responsibility for the one-to-one supervision of the nursing student throughout the entire clinical practicum (2013/55/EU).

The quality of mentor supervision is critical for nursing students in achieving their expected learning outcomes (Papastavrou et al. 2010, Salminen et al. 2010, Löfmark et al. 2012, Bisholt et al. 2014, Flott & Linden 2016, Needham et al. 2016, Valiee et al. 2016). However, the supervision model for mentors varies across countries, healthcare institutions and even practicum wards according to the various implementation models (Warne et al. 2010, Jokelainen et al. 2011b, Bergjan & Hertel 2013, Forber et al. 2016), such as group supervision (Papastavrou et al. 2010, Bergjan & Hertel 2013), one-to-one supervision with an individual mentor (Saarikoski et al. 2009b, Papastavrou et al. 2010) and clinical education wards where students take on more responsibility within student-dedicated patient rooms or take student led placement with several mentors (Staun et al. 2010, Hellström-Hyson et al. 2012, Manninen et al. 2015). One-to-one supervision has been reported as the most successful mentor relationship among students (Papastavrou et al. 2010, Warne et al. 2010) and is thus used in this study.

In previous Finnish studies, the supervision of nursing students in clinical practicum has been examined from the perspectives of students, mentors and teachers, but mainly from the point of view of students focusing on their final assessment (Helminen 2017), ethical problems (Brunou 2009) and the quality of the clinical learning environment and supervision (Saarikoski 2002, Mikkonen 2017).

Clinical role of the nurse teacher

The clinical role of the nurse teacher has been changing since the 2000s (Price et al. 2011, Saarikoski et al. 2013) and is internationally diverse (Brown et al. 2005, Saarikoski et al. 2009b, 2013) and implemented in a variety of ways (Saarikoski et al. 2013). The nurse teacher's clinical role includes pedagogical activities with students, mentors and the staff in the practicum ward (Saarikoski et al. 2008, 2009b), such as supporting, directing, motivating, facilitating, problem solving, troubleshooting, advocating and monitoring (Brown et al. 2005). Thus, the role of the nurse teacher is complex and incudes the roles of a skilled clinical practitioner, liaison person, pedagogical expert, networker, project leader, researcher and integrator of theoretical and practical knowledge (Salminen & Strandell-Laine 2018).

The main aim of the clinical role of the nurse teacher is to support nursing students' clinical learning (Brown et al. 2005, Price et al. 2011, Killam & Heerschap 2013, Pitkänen et al. 2018) but also the mentors' supervision of the nursing students

(Salminen et al. 2013, Helminen et al. 2017, Pitkänen et al. 2018, Salminen & Strandell-Laine 2018). In Finland, there are only a few previous studies that focus on the clinical role of the nurse teachers (Vierula et al. 2016) and these have predominantly used the CLES+T scale (e.g. Saarikoski et al. 2008, Saarikoski et al. 200b, Mikkonen 2017 a, b). However, in Finland CLES+T is broadly used to collect national benchmarking data from hospital districts and the community unit for quality assessment and the subsequent development of healthcare organisations. The findings of this data, containing nearly 20 000 student respondents annually, have revealed that nursing students have low satisfaction with the clinical role of the nurse teacher over several years (Meretoja et al. 2018). In this study, the focus is on the nurse teacher's pedagogical activities in relation to nursing students, i.e. nursing student–nurse teacher cooperation.

Nursing student–nurse teacher cooperation

The aim of the nursing student–nurse teacher cooperation is to support nursing students in their clinical learning and professional development during the clinical practicum (Hentinen 1989, Brown et al. 2005, Lauder et al. 2008b, Mackay & Harding 2009, Saarikoski 2009b, Warne et al. 2010, Price et al. 2011, Babenko-Mould et al. 2012, Löfmark et al. 2012, Killam & Heerschap 2013, Eng & Pai 2015, O'Connor & Andrews 2015, Pitkänen et al. 2018). This support refers to psychological factors and interaction factors, including the nurse teacher's communication, attitude and behaviour – all of which impact on the clinical learning of nursing students (Flott & Linden 2016).

There are wide international, national and even local variations in the nursing student–nurse teacher cooperation methods (Bloomfield et al. 2008, Saarikoski et al. 2013, Gustafsson et al. 2015a, Forber et al. 2016). However, there is no single method, which would be revealed to be superior (Bloomfield et al. 2008, Saarikoski et al. 2013, Gustafsson et al. 2015a, Forber et al. 2016). Traditionally, there have been three main methods used in Europe for this cooperation, in which a nurse teacher: (1) works in a clinical practice as a clinical teacher and as a co-worker of nursing students at the bedside of patients (McSharry et al. 2010, Lin & Shen 2013, Saarikoski et al. 2013); (2) works both in the HEI and in clinical practice (Saarikoski & Leino-Kilpi 2009, Saarikoski et al. 2013), representing the traditional model; and (3) does not work regularly in a clinical practice but is available if difficult situations regarding a student need to be resolved (Saarikoski et al. 2013). In addition to these methods, the most commonly used method in Finland is the one where a nurse teacher works as a liaison person by distance cooperation methods from a UAS via e-mail, phone or from within a virtual learning environment based at an educational institution but has little or no clinical

visits to the nursing students (Saarikoski et al. 2013, Mikkonen et al. 2017a). In this study, the focus is on these distance cooperation methods.

The transfer of nurse education into Higher Education Institutions (HEIs) in the early 1990s created crucial changes in nursing student–nurse teacher cooperation (Barrett 2007, Lauder et al. 2008b, Saarikoski et al. 2008, 2009a, 2009b, Salminen et al. 2010, Gidman et al. 2011, Price et al. 2011, Löfmark et al. 2012, Saarikoski et al. 2013). Nowadays, however, individualized one-to-one cooperation between a nursing student and a nurse teacher is commonly used (Salminen et al. 2010, Gidman et al. 2011, Saarikoski et al. 2009b, 2013), although nurse teacher resources for this cooperation with nursing students are decreasing in Finland and elsewhere in Europe (Saarikoski 2002, Saarikoski et al. 2009b, Jokelainen 2011b, Hall-Lord et al. 2013, Saarikoski et al. 2013, Mikkonen et al. 2017a). In addition, nurse teachers' clinical visits have also been considerably reduced in Finland (Saarikoski et al. 2013, ARENE 2016, Mikkonen et al.2017a, Helminen et al. 2017) and other European countries (Williams & Taylor 2008, Saarikoski et al. 2009b, 2013), even though a higher nursing student–nurse teacher meeting ratio has been shown to be associated with higher levels of student satisfaction with the role of the nurse teacher (Saarikoski et al. 2009b). All these changes have occurred mainly in response to financial rather than pedagogical pressures (Saarikoski et al. 2008, Price et al. 2011, Saarikoski et al. 2013). However, nursing students have reported challenges in this cooperation and a lack of nurse teacher support in clinical learning both nationally (Saarikoski et al. 2013) and internationally (Price et al. 2011, Foster et al. 2014, Gustafsson et al. 2015, Papastavrou et al. 2016b). Nevertheless, previous studies seem to have only rarely studied these changes and there is a paucity of evidence concerning nursing student–nurse teacher cooperation in the clinical practicum, especially in Finland (Vierula et al. 2016).

3.2   Clinical learning outcomes

Learning outcomes are defined by the EC (2017) as "statements regarding what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and responsibility and autonomy". In previous nursing studies, learning outcomes have been defined as something "which students are expected to learn on a course or a realisation which students should know" (Löfmark et al. 2012) and as "specifying what students are expected to learn during an education programme or a course as well as what is required in terms of facilitator support" (Kristofferzon et al. 2013). Moreover, Löfmark et al. (2012) specify clinical learning outcomes as "showing practical skills, abilities to

work independently and take responsibility in clinical practice". In this study, *clinical learning outcomes* comprise individual and contextual outcomes.

3.2.1   Individual outcomes

Definition of competence

Competence is feature commonly applied to professional people, especially in relation to nursing (Garside & Nhemachena 2013). The MOT Oxford Dictionary of English (2005) describes competence as "the ability to do something successfully or efficiently". The EC (2017a) defines competence as a "proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development". However, in the nursing context, competence is a multidimensional and challenging concept that has no clear definition nor a common understanding (Watson 2002, Cowin 2008, Tilley 2008, Smith 2012, Garside & Nhemachena 2013, Nilsson et al. 2014, Blažun et al. 2015, Kajander-Unkuri 2015). According to Meretoja et al. (2004b, 330–331) competence is defined as "*functional adequacy and the capacity to integrate knowledge and skills to attitudes and values into specific contextual situations of practice*". It includes the dimensions of diagnostic functions, therapeutic interventions, the helping role, teaching-coaching, managing situations, ensuring quality and the work role (Meretoja et al. 2004a). According to Watson (2002) and Cowin (2008), competence is an essential component when a nurse's ability to provide effective nursing care is being assessed.

In this study, a generic approach, accepted by several nurse researchers (Watson 2002, Meretoja et al. 2004a, Cowan et al. 2005, Black et al. 2008, Yanhuan & Watson 2011, Garside & Nhemachena 2013) was adopted in the conceptualising of competence. This approach was adopted, because nursing education in Europe aims to equip students with broad, transferable competences (Cowan et al. 2005, Directive 2013/55/EU) and produce nurses responsible for general care (Directive 2013/55/EU), which requires a complex combination of a variety of competences (Nilsson et al. 2014). Generic competence refers to a common set of transferable skills and knowledge regardless of the context (Windsor et al. 2012, Garside & Nhemachena 2013). Thus, the competence definition developed by Meretoja et al. (2004b, 330–331) is used by this study.

Competence as an individual outcome of the clinical practicum

The sufficient competence of nursing students is defined as an expected learning outcome both at their graduation (ICN 2006, WHO 2009, Yanhua & Watson 2011, Hakimzadeh et al. 2013, Shin et al. 2014, Kajander-Unkuri et al. 2014, 2016, Ličen & Plazar 2015, Kajander-Unkuri et al. 2016) and in the clinical practicum evaluations of nursing students (Watson et al. 2002, Löfmark et al. 2006, Salminen et al. 2010, Directive 2013/55/EU, EFN 2015). The development of nursing students' competence can be viewed as a journey (Benner 1982, ICN 2006, Smith 2012) during which the development of competence occurs progressively throughout a nursing degree studies (WHO 2001, Lauder et al. 2008b). Thus, clinical practicum periods with competence-based learning objectives are the 'building blocks' for students who wish to achieve sufficient competence, stated as essential for the readiness of nursing students to transfer to the nursing workforce (WHO 2001, Duchscher 2008, Gallagher & Ousey 2012, Zasadny & Bull 2015, Missen et al. 2016a). In this study, competence is viewed as the student's *individual outcome* attained during the clinical practicum, which is conducted at a clinical practice while in direct contact with patients.

Assessment of the competence of nursing students

The assessment of the competence of nursing students, i.e. fitness for nursing practice, is an integral part of the degree studies, especially in the clinical practicum (Gallagher & Ousey 2012). Nursing students' competence is traditionally assessed both by a mentor's objective observations of their students' professional performance (Ličen & Plazar 2015) and by the students' self-reflection in relation to the curriculum-based individual learning objectives for the clinical practicum. However, this assessment has been called complex (Watson et al. 2002, Tilley 2008, Levett-Jones et al. 2011, Windsor et al. 2012, Kajander-Unkuri et al. 2016) because the competence demands vary between the complex clinical practices (Watson et al. 2002). Thus, skills are emphasised and other dimensions of the competence are commonly omitted in these assessments (Levett-Jones et al. 2011).

In previous studies, various approaches, perspectives and instruments have been utilised to assess nursing students' competence (Ličen & Plazar 2015); both the students' self-assessments and the stakeholders' assessments have been used. However, the prevailing perspective has been self-assessment by the students (Ličen & Plazar 2015), even though the students' ability to conduct this assessment has been the subject of debate (Lauder et al. 2008b). Nevertheless, the focus has been less on the graduating nursing students (Blackman et al. 2007, Lauder et al. 2008b, Kajander-Unkuri et al. 2014, 2015, 2016) and more on the newly graduated nurses' generic competence (Löfmark et al. 2006, Salonen et al. 2007,

Hengstberger-Sims et al. 2008, Wangensteen et al. 2012, Lima et al. 2014, Numminen et al. 2014, Meretoja et al. 2015, Numminen et al. 2015, Kuokkanen et al. 2016, Lima et al. 2016, Numminen et al. 2016, 2017). Thus, there is a lack of evidence in nursing literature regarding the competence development of nursing students during their degree studies (Löfmark et al. 2006, Kajander-Unkuri et al. 2014, Kajander-Unkuri et al. 2016).

According to the self-assessments made by nursing students, their generic competence has been shown to be on a fairly good level during their nursing degree studies (Löfmark et al. 2006, Lauder et al. 2008b, Kajander-Unkuri et al. 2014, 2016), albeit their self-assessments have been rather critical (Blackman et al. 2007). In a recent study by Suarez-Garcia et al. (2018) nursing students reported concerns about their lack of competence. Contradictions between nursing students' self-assessments and their mentors' assessments have also been reported: mentors assessed their students' competence as quite good but at a lower level than the students' self-assessments (Löfmark et al. 2006, Kajander-Unkuri 2016). However, self-assessment has been stated as a critical skill for nurses (Baxter & Norman 2011). In addition, the use of nursing students' self-assessment regarding competence has been stated to have a positive impact on their overall achievements during their nursing degree studies and to complement traditional clinical assessment methods by highlighting student beliefs about areas where they need more assistance in their competence development (Blackman et al. 2007). In this study, the focus is on the generic competence of students as assessed by the students themselves and their mentors.

Definition of self-efficacy

There is no consensus on the exact description of self-efficacy. The MOT Oxford Dictionary of English (2005) describes the concept as "the ability to produce a desired or intended results". In this study, social cognitive theory by Bandura (1997), which is accepted by several nurse researchers (Babenko-Mould et al. 2012, Rowbotham & Scmitz 2013, Orgun & Karaoz 2014, Rowbotham & Owen 2015), was adopted in the conceptualizing of self-efficacy. Perceived self-efficacy is an essential element of Bandura's (1977) social cognitive theory and refers to "beliefs in one's capabilities to organize and execute the course of action required to produce given attainments" (Bandura 1997, 3). Self-efficacy refers to beliefs about specific behaviours in specific situations but does not concern one's intention to perform a task, which is essential for other self-related concepts like self-assessment, self-concept, self-esteem, and outcome expectancy (Uzuntiryaki & Aydin 2009). Furthermore, perceived self-efficacy impacts on how consistently and effectively one can apply what one knows (Bandura 1997). The approach by Bandura (1997), which stresses that self-efficacy is also related to the support one

receives from others, is also accepted by Pike and O'Donnell (2010) and is also adopted by this study. According to this approach, telling a student that she or he can succeed in a given performance improves a student's beliefs that a task can be achieved and simultaneously raises the self-efficacy beliefs of the student (Pike & O'Donnell 2010). Moreover, students' self-efficacy has been stated as a prerequisite for later success after graduation (Bandura 1997, 237)

According to Bandura (1997) there are four sources related to the self-efficacy of students: (1) prior experiences with the performance in question, (2) the observation of the performance of their peers, (3) persuasive communication and evaluative feedback and/or discouragement received from others and (4) emotional states such as anxiety and stress. Self-efficacy has been used to predict students' motivation, emotions, cognitive and self-regulative processes as well as performance. The first source of self-efficacy has been reported to be the strongest contributor. Nevertheless, students encountering new tasks to be performed and for which they have no clear criteria – as commonly happens in the clinical practicum – use persuasive communication and feedback more strongly when formulating their self-efficacy beliefs, but this can be maintained only if a successful experience is achieved. (Bandura 1997.)

Sell-efficacy as an individual outcome in the clinical practicum

Nursing students' self-efficacy has been stated as a goal (Lauder et al. 2008b) and the underlying principle of nursing education (Rowbotham & Owen 2015). Moreover, high self-efficacy has been stated as a prerequisite for success in achieving the expected competence before graduation (Lauder et al. 2008b, Rowbotham & Owen 2015) and it also helps predict the rate at which RNs will leave the nursing profession (Van Wayenberg et al. 2015). In this study, self-efficacy is viewed as the *individual outcome* of a student that is attained during their clinical practicum, conducted at a clinical practice while in direct contact with patients. In addition, *self-efficacy* refers to a student's beliefs in their own ability to execute a clinical performance task during the clinical practicum.

Assessment of the self-efficacy of nursing students

Nursing students' self-efficacy has not received a great deal of attention in previous studies (Cheraghi et al. 2009, Rowbotham & Owen 2015). Nursing students' self-efficacy has been examined by means of student self-assessment, mostly in the context of the clinical practicum (e.g. Babenko-Mould 2004, Cheraghi et al. 2009, Jones & Sheppard 2011, Babenko-Mould et al. 2012, Chesser-Smyth & Long 2013, Rowbothman & Owen 2015) and rarely in the classroom environment (Rowbotham & Schmitz 2013).

Nursing students' self-efficacy has been assessed both as general perceived self-efficacy (Lauder et al. 2008a, 2008b), student self-efficacy (Rowbotham & Schmitz 2013, Rowbothman & Owen 2015) and in relation to professional nursing practice competence (Babenko-Mould et al. 2004, 2012, Kennedy et al. 2015), computer mediated learning (Babenko-Mould et al. 2004), clinical performance (Cheraghi et al. 2009) and academic challenges in the classroom (Rowbothman & Scmitz 2013). According to previous studies, nursing students assess their self-efficacy as being on a fairly good level in the context of the clinical practicum (Babenko-Moud et al. 2004, Jones & Sheppard 2011, Chesser-Smyth & Long 2013) and in nursing education in general (Lauder et al. 2008b).

Social cognitive theory has been used in previous nursing education studies, (Lauder et al. 2008b, Hakimzadeh et al. 2013), which report associations between nursing students' self-efficacy and their self-assessed competence, but no consensus on the direction of the relationship exists (Lauder et al. 2008b). Moreover, it has been stated that self-efficacy may act as a moderator between the earlier clinical practicum experiences and competence or it can also be seen as an outcome. Nevertheless, self-efficacy alone does not impact on learning outcomes although student motivation plays a role in the learning outcomes reached in the clinical practicum (Pike & O'Donnell 2010, Rowbothman & Owen 2015).

The importance of teacher support and feedback in facilitating student self-efficacy has been stated by Bandura (1997) and also in previous nursing education studies (Lauder et al. 2008a, Cheraghi et al. 2009, Kenny et al. 2012, Chesser-Smyth & Long 2013, Rowbotham & Schmitz 2013). Nevertheless, few studies have examined the association between a nurse teacher's clinical role and nursing students' self-efficacy during a clinical practicum (Babenko-Mould et al. 2012, Rowbothamn & Schmitz 2013, Kennedy et al. 2015).

3.2.2   *Contextual outcomes*

Definition of the quality of the clinical learning environment

The quality of the clinical learning environment (CLE) is a widely examined area, but a common framework or definition of the quality of the CLE has still not been agreed upon (Salminen et al. 2010, Henderson et al. 2012, Flott & Linden 2016, Saarikoski & Strandell-Laine 2016). The CLE is defined as a multi-level and complex network comprising several factors that influence nursing students' clinical learning in a complex way (Saarikoski 2002, Papastavrou et al. 2010, Bergjan & Hertel 2013, Hooven 2014, Tomietto et al. 2016, Lee et al. 2018a, Saarikoski 2018). According to Lee et al. (2018a) these factors are interpersonal,

socio-cultural, instructional, environmental, emotional and physical factors of the clinical learning environment that have a complex and causal relationship with each other.

Flott and Linden (2016) describe the CLE as consisting of four main elements: physical space, psychological and interaction factors, the organisational culture, and teaching and learning components with effective instructions and student engagement. From the perspective of physical space, the clinical learning environment includes both (1) clinical settings, e.g. hospitals, primary healthcare, (Flott & Linden 2016), psychiatric care, nursing homes and patient homes (Bisholt et al. 2014) and (2) simulation centres (Flott & Linden 2016), which provide an authentic environment for nursing students in which to develop the knowledge, skills, attitudes and values of a registered nurse (Bisholt et al. 2014, Levett-Jones et al. 2015). In this study, the physical space of the *clinical learning environment* is in-patient and out-patient hospital wards where clinical training (Directive 2005/36/EC and Directive 2013/55/EU) occurs during the clinical practicum of the nursing students.

Previous studies reveal that the clinical learning environment (Papastavrou et al. 2010, Flott & Linden 2016), the supervision given by mentors and the cooperation of nurse teachers with students (Löfmark et al. 2012, Needham et al. 2016) are all critical for nursing students in offering meaningful learning opportunities (Saarikoski & Leino-Kilpi 2002) that will help to achieve the expected learning outcomes (Papastavrou et al. 2010, Salminen et al. 2010, Löfmark et al. 2012, Bisholt et al. 2014, Kajander-Unkuri et al. 2014, Flott & Linden 2016, Needham et al. 2016, Mansutti et al. 2017). Thus, the definition by Saarikoski et al. (2008) on *the quality of the clinical learning environment* is used in this study because it comprises (I) the clinical learning environment, (II) the supervisory relationship with the mentor and (III) the role of the nurse teacher (Saarikoski et al. 2008). It includes the dimensions of the pedagogical atmosphere, the leadership style of the ward manager, the premises of the nursing on the ward, the supervisory relationship with the mentor and the role of the nurse teacher (Saarikoski et al. 2008).

Quality of the clinical learning environment as a contextual outcome in the clinical practicum

The quality of the CLE is seen as a prerequisite for nursing students learning in clinical practice (Pitkänen et al. 2018). In this study, *the quality of the clinical learning environment as experienced by nursing students* is viewed as a contextual outcome of the clinical practicum.

Assessment of the quality of the clinical learning environment

The quality of the CLE has been examined from the points of view of students, mentors and nurse teachers (e.g. Salminen et al. 2010, Chuan & Barnett 2012, Courtney-Pratt et al. 2012, Ford et al. 2016). Most of the previous studies are descriptive ones, focusing on student experiences (e.g. Saarikoski et al. 2009a, Papastavrou et al. 2010, Salminen 2010, Warne et al. 2010, Henderson et al. 2012, Carlson & Idvall 2014, D'Souza et al. 2015, Mikkonen et al. 2017a, 2017b, Shivers et al. 2017, Pitkänen et al. 2018). However, the patients' point of view is rarely examined (Saarikoski et al. 2018). Previous studies reveal that nursing students are commonly satisfied with the quality of the CLE (Papastavrou et al. 2010, Warne et al. 2010, Courtney-Pratt et al. 2012, Ford et al. 2016, Anthone et al. 2017, Shivers et al. 2017, Meretoja et al. 2018, Pitkänen et al. 2018) and they value and look forward to its learning possibilities (Saarikoski et al. 2007, Warne et al. 2010, Rowbotham & Owen 2015, Ford et al. 2016, Meretoja et al. 2018, Pitkänen et al. 2018, Salminen & Strandell-Laine 2018).

The pedagogical atmosphere in the ward (e.g. Saarikoski & Leino-Kilpi 2002, Warne et al. 2010, Bisholt et al. 2014, Papastavrou et al. 2016b, Doyle et al. 2017) and the supervisory relationship with the mentor (Saarikoski et al. 2002, 2003, 2008, Warne et al. 2010) have an essential impact on the quality experienced of the CLE and may also affect the rate at which students leave the nursing profession (Jokelainen et al. 2011a, 2011b).

According to previous studies, nursing students face difficult challenges on practicum wards (Gidman et al. 2011, Pulido-Martos et al. 2012, Ratanasiripong et al. 2012, Killam & Heerschap 2013, Rowbotham & Owen 2015, Wu et al. 2015, Doyle et al. 2017, Lee et al. 2018a, O'Connor & Andrews 2018, Suarez-Garcia et al. 2018). In the beginning of a clinical practicum students often enter a new and complex CLE (Gidman et al. 2011, Pulido-Martos et al. 2012, Lee et al. 2018a) and also face new daily practices and caring protocols (Pulido-Martos et al. 2012) as well as unfamiliar staff, patients and families (Rowbotham & Owen 2015). In relation to that, nursing students have increasingly reported poor practices in practicum wards (Bickhoff et al. 2017, Courtney-Pratt et al. 2018), such as the physical and emotional abuse of the students, patients and clinical staff (Rees et al. 2014, Courtney-Pratt et al. 2018). Nursing students have also reported feelings of being unsupported by nurses while on the practicum ward (Ford et al. 2016, Anderson et al. 2018). Moreover, students often face incongruence between an ideal practice learned in a theoretical studies prior to the clinical practicum and the actual learning situation (Pulido-Martos et al. 2012, Rees et al. 2014) as well as between perceived expectations regarding student experience and the actual experience of students (Ford et al. 2016) at the clinical practice. The large amount

of time nursing students spend in the clinical practicum and the reports of the challenges they experience indicate that is essential to consider how to support students in their clinical learning within CLEs.

Thus, the supervision given by nurse teachers has special importance in supporting nursing students in their CLE experience and in improving the clinical learning of nursing students (Salminen et al. 2010, Courtney-Pratt et al. 2012, Löfmark et al. 2012, Rowbotham & Owen 2015, Ford et al. 2016, Lee et al. 2018a). However, it seems that the existing nursing student–nurse teacher cooperation methods do not fulfil nursing student needs for nurse teacher support (Saarikoski et al. 2013, Foster et al. 2014) as a resource during their clinical learning (Gustafsson et al. 2015, Papastavrou et al. 2016b). This lack of support has been extensively reported in previous studies on nursing students (Brown et al. 2008, Wu & Lai 2009, Gidman et al. 2011, Price et al. 2011, Löfmark et al. 2012, Killam & Heerschap 2013, Saarikoski et al. 2013, Foster et al. 2014, Gustafsson et al. 2015, Papastavrou et al. 2016b), especially among students at the beginning of their nursing degree studies (Brown et al. 2008, Gidman et al. 2011).

3.2.3   *Factors associated with clinical learning outcomes*

Nursing students' competence, self-efficacy and the quality experienced of the clinical learning environment seem to be associated with several individual and contextual related factors based on previous studies. These associations are described in this chapter according to the nursing students' clinical learning outcomes.

Factors associated with nursing students' competence

Individual factors such as the female gender of nursing students (Hakimzadeh et al. 2013), older age (Salonen et al. 2007), the higher level of the current degree programme (Bartlett et al. 2000), a student's previous professional qualifications (Kajander-Unkuri et al. 2014) and prior (Wangesteen et al. 2012, Hakimzadeh et al. 2013) and current (Kajander-Unkuri et al. 2014) work experience in healthcare have shown a positive association with nursing student and GNS competence development. Moreover, a nursing student's interest (Hakimzadeh et al. 2013), intention to stay in the nursing profession (Kajander-Unkuri 2015), higher self-efficacy (Lauder et al. 2008b, Cherahgi et al. 2009, Hakimzadeh et al. 2013, Karabacak et al. 2013, Pijl-Zieber et al. 2014, Eng & Pai 2015), critical thinking (Wangesteen et al. 2010, 2012) and self-reflection (Pai 2015) are reported to be positively associated with the competence development of nursing students and GNSs.

Contextual factors such as a nursing students' positive experiences of the quality of the pedagogical atmosphere (Hakimzadeh et al. 2013, Kajander-Unkuri et al. 2014), the mentor supervision on the practicum ward and the nursing curriculum as a whole (Kajander-Unkuri et al. 2014) have shown a positive association with the competence development of nursing students. Moreover, for GNSs, the practice environment (Numminen et al. 2015), the frequency of the use of a specific competence (Hengstberger et al. 2008, Lima et al. 2014) as well as the qualifications provided by nursing education to practice in the nursing profession (Kajander-Unkuri et al. 2014) have been reported as being positively associated with competence development.

Factors associated with nursing students' self-efficacy

Individual factors such as nursing students' prior work experience in healthcare (Hakimzadeh et al. 2013) and higher competence (Cheraghi et al. 2009, Pijl-Zieber et al. 2014, Eng and Pai 2015) have been reported to be positively associated with the self-efficacy of nursing students.

Contextual factors such as the quality of the CLE as experienced by nursing students (Hakimzadeh et al. 2013), the quality of the nursing practice, nursing performance on the ward (Lee and Ko 2010), support from faculty, mentor, peers and family (Lauder et al. 2008b) as well as empowering teaching behaviour from nurse teachers (Babenko-Mould et al. 2012) have all been reported as being positively associated with the higher self-efficacy of nursing students.

Factors associated with the quality of clinical learning environments

Individual factors such as the length of term of the studies (Pitkänen et al. 2018), prior work experience in healthcare (Carlson and Idvall 2014), the degree programme (Pitkänen et al. 2018) and the type of educational institution (Warne et al. 2010) have been reported as being positively associated with the quality of CLEs experienced by nursing students.

Contextual factors such as the clinical practicum settings (Bisholt et al. 2014), the mentor's supervision method (Saarikoski et al. 2007, Saarikoski et al. 2009b, Papastavrou et al. 2010; Warne et al. 2010, Antohe et al. 2016), the pedagogical atmosphere on the ward (Saarikoski & Leino-Kilpi 2002, Warne et al. 2010, Bisholt et al. 2014, Doyle et al. 2017), the duration of the clinical practicum and the frequency of interaction during the supervisory relationship with the mentor (Warne et al. 2010, Pitkänen et al. 2018), private unscheduled sessions with the mentor (Pitkänen et al. 2018), the planning of learning outcomes with the mentor (Pitkänen et al. 2018), the leadership style of the ward manager (Bisholt et al. 2014), conducting the final evaluation in cooperation with the nurse teacher and

mentor, pre-practicum theoretical teaching (Saarikoski et al. 2013), the supervisory relationship between mentor and nursing student (Saarikoski et al. 2008, Papastavrou et al. 2010, Warne et al. 2010, Bos et al. 2014, Needham et al. 2016, Valiee et al. 2016), cooperation between nurse teachers and the clinical staff from the clinical practice (Saarikoski 2002, Löfmark et al. 2012, Bisholt et al. 2014) and the frequency of the meetings between nursing students and nurse teachers (Saarikoski et al. 2008) have all been reported to be positively associated with the quality of the CLE as experienced by nursing students.

It seems that, there are several individual and contextual factors associated with the nursing students' clinical learning outcomes. However, regarding individual factors, the competence and self-efficacy of nursing students are factors that are clearly associated with each other. Moreover, the nursing students' prior work experience in healthcare has been reported to be associated with both students' competence and self-efficacy as well as with the quality of the CLE.

3.3   Previous studies on nursing student–nurse teacher mobile cooperation during the clinical practicum

The original systematic literature search for this study was performed in Phase I on four international electronic databases: PubMed/Medline, CINAHL, PsycINFO and ERIC. The literature search focused on mobile device use in the nursing student–nurse teacher cooperation during the clinical practicum, especially regarding how they have been used and for what purposes. The same search terms were used across databases (Table 3). The searches were performed based on information from the launch of four international electronic databases up to and including March 2014 in order to obtain a broad overview of the literature on the topic from the initiation of mobile device use in the clinical practicum. These searches were complemented by manual searches in the reference lists of the articles. A total of 11 studies were included in the original integrative review and the quality of the included studies was appraised (Paper I).

For this summary, the search was updated with an identical strategy and covered the years 2014–July 2018. The updated electronic database searches resulted in 203 identified references. The duplicates (n=32) were removed upon initial screening. Altogether 171 references were screened by the researcher herself on the title and abstract level and further screened on the full-text level using the same inclusion and exclusion criteria as in Phase I. As a result of the updating of the original literature review (Paper I), 17 studies were included in the final integrative review in this Summary.

Table 3. Search terms used for the systematic database searches.

Key concepts	Search terms
Nursing student	student*, nurse, nursing
Nurse teacher	teacher*, tutor*, instructor*, facilitator*, lecturer*, educator*, faculty, university
Clinical practicum	practice, clinical, placement*
Mobile device	personal digital assistant*, PDA*, handheld*, mobile, device*, wireless, smartphone*, tablet PC*, tablet computer*
Cooperation	support*, isolation, interacti*, communicat*, cooperat*, connect*, collaborat*, learning, m-learning, teaching.

Mobile device use in nursing student–nurse teacher cooperation

Based on the results of the integrative review, various mobile devices have been used in the nursing student–nurse teacher cooperation with varying durations of use from a few weeks up to 16 months. Furthermore, different concepts have been used when referring to the mobile technology used in the studies, causing difficulties in the understanding and interpretation of the study findings. A clear description of the software used as a novel alternative in the student–teacher mobile cooperation was missing from several studies. (Table 4.)

Based on previous studies, nursing students have used their own and loaned mobile devices and used several different types of software for facilitating nursing student–nurse teacher cooperation. The reason for using one's own or a loaned device are not described, thus the mobile technology itself has not been the main focus of the previous studies, rather the outcomes of its use. The mobile technologies used in the studies reflect the technology available at the time of the study. Thus, no innovative mobile technology has been tested or evaluated in any of the studies. (Paper I, Table 4). The common trend is that one software is used by the nursing students and nurse teacher, but there are also studies that use several software simultaneously (Table 4). The most common software used is the mobile learning environment administered by the educational institution.

Through a manual search, one web mobile application developed for the purposes of connecting practical nurse student, teachers and mentors during workplace training was identified. This mobile application eTaitava was originally developed in Finland for vocational upper secondary education (Mettiäinen & Karjalainen 2011). The experiences of the nursing students who used eTaitava during their clinical practicum have been examined and promising findings were found (Mettiäinen 2012, 2015), but the further evaluation of its effectiveness for clinical learning is lacking in the context of HEIs.

To maintain the effective use of mobile technologies, there is a need for adequate training in software functionalities before its actual use, something which was asked for by nursing students in several studies (Garrett & Jackson 2006, Bogossian et al. 2009, Kenny et al. 2009, Wu & Lai 2009, Wyatt et al. 2010, Wu & Sung 2014, Wu 2014a). Thus, technology literacy varied among nursing students irrespective of the mobile device and software used or the year of the study. Mobile device use was associated with several factors, which either hindered or facilitated their use in nursing student–nurse teacher cooperation (Paper I, Figure 2). In general, mobile device use seems to have benefits for nursing student–nurse teacher cooperation and it has been seen as interesting and valuable by both nursing students and nurse teachers (Paper I).

Purpose of mobile technology use in student–teacher cooperation

Mobile technology has been used for various purposes in the nursing student–nurse teacher cooperation during the clinical practicum (Table 4). Based on previous studies, nursing students use them mostly as reference tools and less frequently for the purposes of nursing student–nurse teacher cooperation. Nevertheless, several purposes for mobile technology use in student–teacher cooperation were found.

The most common purpose of mobile technology use was to facilitate student communication with the nurse teacher (Garrett & Jackson 2006, Mackay & Harding 2009, Wu & Lai 2009, Wu & Sung 2014, Wu 2014a, Martyn et al. 2014, Willemse 2015) and peers (Wu & Lai 2009, Martyn et al. 2014, Wu 2014a, Willemse 2015), but also to receive nurse teacher support and feedback (Bogossian 2009, Mackay & Harding 2009, Young et al. 2010, Wu 2014a, Lai & Wu 2016) and enhance the clinical learning of students (Garrett & Jackson 2006, Wyatt et al. 2010, Willemse 2015, Mackay & Harding 2017). (Figure 2.) Nurse teachers used mobile devices for delivering timely, in-depth and asynchronous cooperation to nursing students. (Paper I, Table 4.)
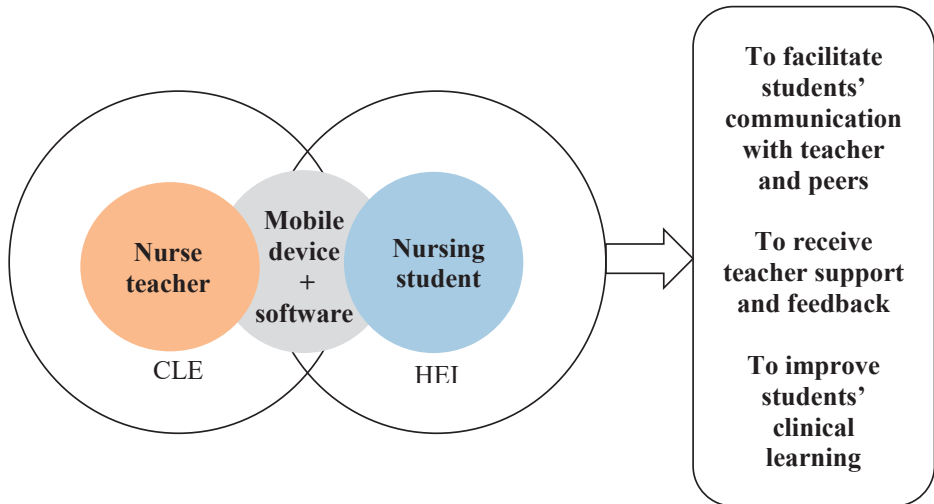
Figure 2. Purpose of the nursing student–nurse teacher mobile cooperation.
HEI = higher education institution; CLE = clinical learning environment

Table 4. Mobile devices, software, duration of the use, the users and the purpose of the mobile application use during the clinical practicum in the previous studies.

Author/ Year	Mobile device	Software	Duration	User	Purpose of the use of mobile technology
Garrett & Jackson 2006	Loaned personal digital assistant (PDA)	Clinical e-portfolio. Features of contacts, shift times, resources, learning opportunities	3 months	NS, NT	To facilitate access to clinical practicum information, to record learning experiences and to interact with teachers.
Bogossian et al. 2009	Loaned tablet computer	Clinical practice performance e-portfolio	Not described	NS	To undertake and demonstrate the expected competences and to receive feedback from teachers.
Kenny et al. 2009	Mobile device	Access to several applications (applications not described)	5 weeks		To enhance clinical learning.
Mackay & Harding 2009	Student's mobile phone	Text message	Not described	NS, NT	To provide teacher support to motivate, encourage and communicate with students.
Wu & Lai 2009	Student's PDA	Handheld learning environment. Features of announcement, patient's ABC, interview, portfolio, symptom assessment, reflective journal, dictionary, resources, forum, help	3 weeks	NS, NT	To support information recording, organising ideas, assessing patients, interaction with teacher and peers.
Wyatt et al. 2010	PDA	Mobile learning environment with several applications (applications not described)	16 months	NS, NT	To enhance clinical learning.
Young et al. 2010	Student's mobile phone	Text message	3 months	NS, NT	To provide teacher support.
Wu & Sung 2014	Student's device	Applications offered as part of Google+ for communication, position and route-planning and article sharing	4 weeks	NS, NT	To share, save and discuss relevant topics with the teacher during home visits.

Author/ Year	Mobile device	Software	Duration	User	Purpose of the use of mobile technology
Wu 2014a	Loaned tablet computer	Applications offered as part of Google+ (applications not described)	4 weeks	NS, NT	To real-time support, communication and interaction with teacher and peers, information sharing.
Wu 2014b	Tablet computer	Mobile learning software (not described)	4 weeks	NS, NT	To guide self-reflection, self-regulated learning, to monitor learning progress, to provide guidance and feedback at appropriate times. To adjust and design teaching strategies.
Martyn et al. 2014	Loaned portable media player (iPod)	Moodle	Not described	NS, NT	To enhance student interaction with content, teachers and peers.
Willemse 2015	Student's mobile device	WhatsApp	7 weeks	NS, NT	To communicate with peers and teacher and to enhance and promote clinical learning.
Lai & Wu 2016	Loaned netbook	e-portfolio. Features of introduction, forum, reflection, samples, sharing, artifacts, resources for patient care (therapy strategies, symptom assessment, nursing diagnosis & plans)	3 weeks	NS, NT	To improve learning and assessment.
MacKay & Harding 2017	Tablet computer (iPad)	Access to several applications (applications not described)	8 months	NT	To support clinical teaching and the education of students.

NS=nursing student; NT=nurse teacher

Acceptability of mobile device use in nursing student–nurse teacher cooperation

Based on the results of the integrative review, there are two key areas of interest in the previous studies: (1) Nursing students' perceptions and satisfaction with the use of mobile technology during the clinical practicum as well as (2) the benefits and harms of mobile technology use during the clinical practicum (Paper I).

The usability of mobile devices was tested in one study (Kenny et al. 2009), revealing that it is easy to learn and use. From the point of view of utility, the use of mobile devices has been reported to facilitate the nursing student–nurse teacher cooperation during the clinical practicum. The acceptability of and satisfaction with mobile device use seems to be high among nursing students, but ward culture and connectivity problems have hindered the full use of mobile devices during the clinical practicum. Thus, the nursing students' actual use of the mobile devices has mostly occurred outside clinical practicum hours. (Paper I.)

A critical appraisal of previous studies on the use of mobile devices in nursing student–nurse teacher cooperation during the clinical practicum

A critical appraisal of previous studies on the use of mobile devices in nursing student–nurse teacher cooperation during the clinical practicum reveals weaknesses in study designs, samples, instruments and results (Paper I, Appendix 1). The majority of the studies were conducted in the context of a clinical practicum (n=15) except for two of the studies (Kenny et al. 2012, Willemse & Bozalek 2015) conducted in an educational institution. The most common design among the studies was a quasi-experimental design (n=11) mainly with one group post-test measures. Two of the studies had an experimental design (Kenny et al. 2009, Wu 2014b). Furthermore, the qualitative design has become an increasing trend (n=4) between 2015 and 2018. Moreover, the majority of the studies were conducted without a longitudinal design or follow-up. Consequently, the existing evidence is mostly derived from descriptive mixed method studies with surveys, interviews and focus groups, rather than experimental studies. Consequently, the studies are mostly uncontrolled single-cohort studies, representing Level II–VI evidence sources (Polit & Beck 2012).

The discussion of research ethics was commonly incomplete in the studies. Questions regarding the creation and maintaining of patient privacy when using mobile technologies in a clinical practice were not raised. In addition, the voluntary participation (Bogossian 2009, Mackay & Harding 2009, Wu & Sung 2014) and the informed consent procedures for enrolling participants in the studies was also omitted from several studies (Kenny et al. 2009, Wu & Lai 2009, Wu & Sung 2014, Kenny et al. 2012).

3.4 Summary of the literature review

In nursing education, more attention needs to be paid to facilitating nursing student–nurse teacher cooperation during the clinical practicum. Effectiveness in this enhanced cooperation might have positive consequences both for nursing students' clinical learning outcomes and thus patient outcomes. The literature review reveals that nursing student–nurse teacher cooperation is increasingly conducted by distance cooperation methods but that the use of mobile technology to facilitate this cooperation is only evolving slowly. Moreover, robust evidence to support educational and policy decision-making for its wider integration into nursing education is lacking.

The results of previous studies on student experiences with mobile technology use during the clinical practicum are encouraging. However, nursing student–nurse teacher mobile cooperation requires more research and there is a need for the development of a user-friendly mobile application to meet the needs and expectations of nursing students. Studies with randomised controlled trial designs are needed to understand the effectiveness of nursing student–nurse teacher mobile cooperation with respect to nursing students' competence, self-efficacy and how they experience the quality of the CLE as well as the possible factors associated with the clinical learning outcomes of this cooperation. Nursing students' success in clinical learning is one of the major explicit goals of nursing education and requires vastly more attention from future studies.

4   PURPOSE OF THE STUDY AND RESEARCH QUESTIONS

The purpose of this three-phase study (Figure 3, Page 47) was to describe the use of mobile devices in nursing student–nurse teacher cooperation, to develop a novel alternative, i.e. mobile cooperation intervention (MCI) for nursing student–nurse teacher cooperation in a clinical practicum and to evaluate its effectiveness on nursing students' clinical learning outcomes. Moreover, the purpose was to examine the acceptability of the MCI from the perspective of the nursing students. The ultimate goal is to improve the quality of nursing education and thus the outcomes of patient care. The research questions addressed were as follows:

1. What is the evidence and quality of previous studies regarding nursing student–nurse teacher mobile cooperation?
    a. How have mobile devices been used in the cooperation? (Paper I, Summary)
    b. For what purposes have mobile devices been used in the cooperation? (Paper I, Summary)
    c. What is the methodological quality of previous studies on the use of mobile devices in nursing student–nurse teacher cooperation? (Paper I, Summary)

2. What is the effectiveness of the MCI on the clinical learning outcomes of the nursing students?
    a. What is the effectiveness of the MCI on individual outcomes? (Paper II, III, Summary)
    b. What is the effectiveness of the MCI on contextual outcomes? (Paper II, III)
    c. What are the factors associated with clinical learning outcomes regarding the MCI? (Paper III, Summary)

    The following hypotheses were tested: The MCI statistically significantly improves
       H1: individual outcomes in the intervention group,
       H2: contextual outcomes in the intervention group compared to the control
          group.

3. What is the acceptability of the MCI from the perspective of intervention recipients?
    a. What is the commitment to the MCI? (Paper II, IV)
    b. What are the experiences of the MCI? (Paper II, IV)

The purpose was to develop a mobile cooperation intervention (MCI) to facilitate nursing student–nurse teacher cooperation and to evaluate the effectiveness and acceptability of the MCI from the perspective of nursing students.

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| **Phase I (2013–2014)** | **Paper I** |
| **EVIDENCE BASE** | |

Purpose: to identify and appraise previous studies on the use of mobile devices in the nursing student–nurse teacher cooperation during the clinical practicum
Sample: Literature review PubMed /Medline, CINAHL, PsycINFO and ERIC until March 2014
Design: Integrative literature review (n=11)

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| **Phase II (2014–2018)** | **Paper II, IV, Summary** |
| **DEVELOPMENT AND PILOTING** | |

Purpose: to develop and pilot a novel and complex MCI

Purpose: to develop the App and evaluate its technical performance and usability **Sample:** students (n=6), nurse teacher (n=1) **Design:** user-centred design and one-group post-test	**Purpose:** to further develop the T-subscale of the CLES+T scale in order to assess the outcome of the usage of the App and to explore the content validity of the T_2-subscale **Sample:** two rounds of expert panels (n=8) **Design:** descriptive

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| **Phase III (2015–2018)** | **Papers III, IV, Summary** |
| **EVALUATION** | |

Purpose: to implement the MCI

Purpose: to evaluate the effectiveness of the MCI **Sample:** 102 nursing students, 95 mentors **Design:** parallel group randomized controlled trial	**Purpose:** to evaluate the acceptability of the MCI **Sample:** 52 nursing students **Design:** mixed methods and one-group post-test	**Purpose:** to identify previous studies of mobile device use in nursing student–nurse teacher cooperation during the clinical practicum **Sample:** Literature review PubMed /Medline, CINAHL, PsycINFO and ERIC 2014–July 2018 **Design:** Integrative literature review (n=6)

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To improve the quality of nursing education and consequently the outcomes of patient care
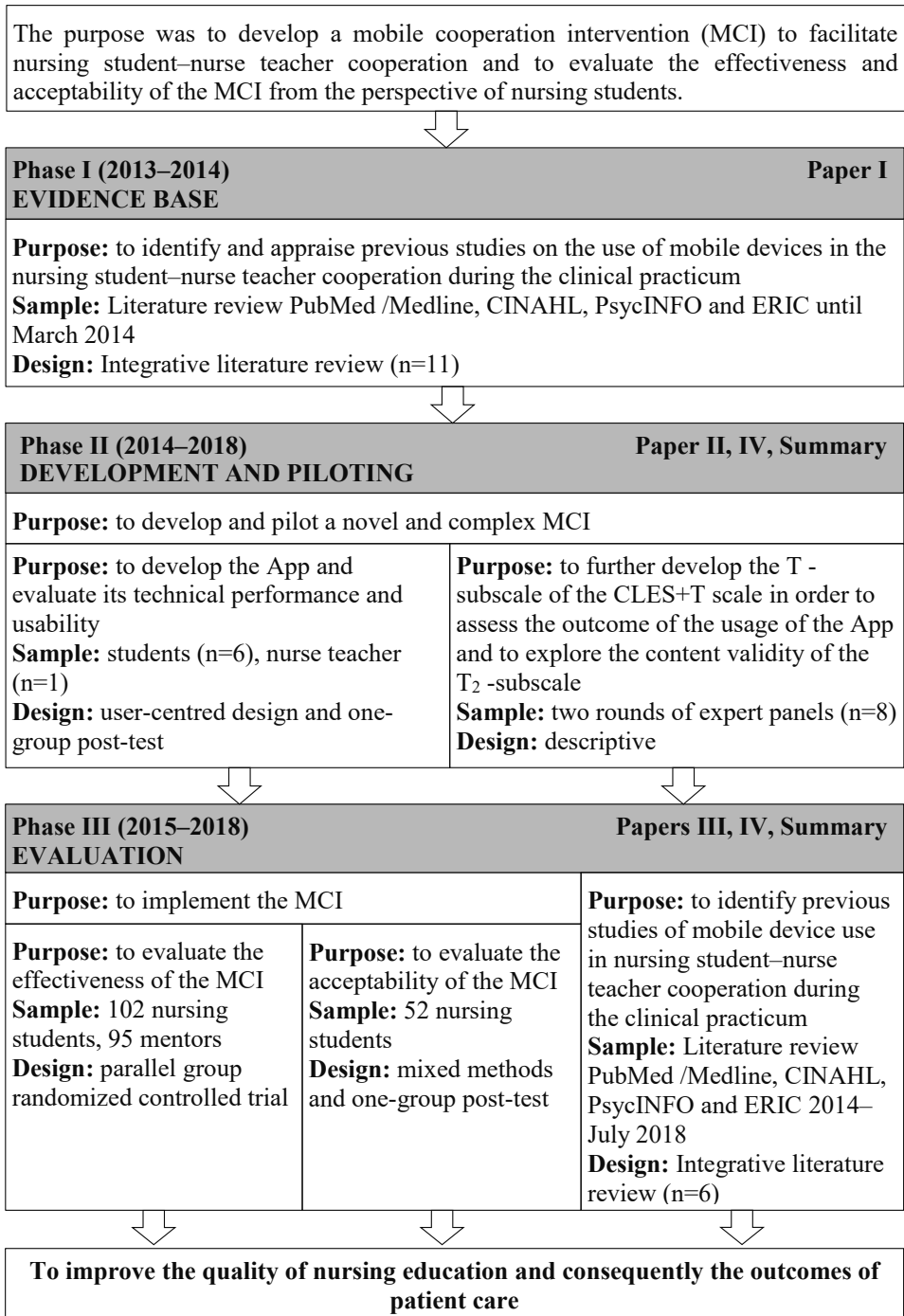
Figure 3. Study Phases I–III.

5   MATERIALS AND METHODS

This chapter describes the materials and methods used when addressing the research questions (1–3) of the three phases of the study (Phase I, II and III). The study was conducted with various designs, samples, settings, data collection and methods of analysis, which are described in this chapter according to the three study phases (Table 5). In addition, ethical considerations are discussed.

Table 5. Research questions, study designs, settings, samples, the data collection methods and the method of analysis of this study.

Phase	Paper	Research question	Design	Setting	Sample	Data collection methods	Data analysis
I 2013–2014	I	1a,b,c	Integrative literature review	Previous studies on mobile device use in student–teacher cooperation	Empirical research papers (n=11)	Systematic literature search from PubMed /Medline, CINAHL, PsycINFO and ERIC	Inductive thematic analysis. Critical appraisal.
II 2014–2015	II and Summary	2b	Descriptive	UAS, university, clinical practice	Expert panels (n=8)	$CLES+T_2$ versions T_1 and T_2	Statistical analysis: Descriptive. Content validity index. Inductive content analysis.
II 2014–2018	II	3b	User-centred design and one-group post-test	Clinical practicum	Students (n=6), nurse teacher (n=1)	Peq with SUS	Statistical analysis: Descriptive. Inductive content analysis.
III 2015–2018	III	2a,b,c	Parallel-group randomised controlled trial	Clinical practicum	Students (n_{IG}=52, n_{CG}=50)	Structured questionnaire: socio-demographics, NCS, SECP, $CLES+T_2$	Statistical analysis: Descriptive, statistical modelling.
III 2015–2018	Summary	2a	Parallel-group randomised controlled trial	Clinical practicum	Mentors (n_{IG}=40, n_{CG}=32)	Structured questionnaire: Socio-demographics, NCS	Statistical analysis: Descriptive, statistical modelling.
III 2015–2018	IV	3a,b	Mixed methods and one-group post-test	Clinical practicum	Students (n_{IG}=52)	Structured questionnaire: Peq with SUS, Essay	Statistical analysis: Descriptive, statistical modelling. Inductive thematic analysis.

5.1   Study design, setting and sampling

The study had strong nursing student involvement throughout all study Phases I–III (Table 6).

Table 6. Nursing student samples in the study Phases I–III.

Phase Years	Purpose of the nursing student's involvement	Sample	Sampling technique
Phase I 2013–2014	To create an evidence base for the further development of the CLES+T scale and the development of the MCI.	n=11*	
Phase II 2014–2015	To develop the App	n=6	Purposive
	To evaluate the content validity of the T_2-subscale	n=2	Purposive
	To pilot the MCI, CLES+T_2 scale, background questions and structured questions as well as the questionnaire instructions developed for this study	n=6	Purposive
	To review the SECP instrument back-translation by employing a native language speaker	n=1	Purposive
Phase III 2015–2018	To evaluate the effectiveness of the MCI	n=102	Convenience
	To evaluate the acceptability of the MCI	n=52	Convenience
	To evaluate the experiences of the MCI	n=10	Convenience

studies included in the original integrative review

In Phase I, an integrative literature review design (Whittemore & Knafl 2005) was used to synthesize existing evidence on the use of mobile devices in nursing student–nurse teacher cooperation during a clinical practicum (Paper I). Since, no recent relevant review of the topic of interest existed (Craig et al. 2013), an integrative review was regarded as suitable due to its potential to provide a comprehensive understanding of the phenomenon and provide flexibility for combining diverse methodologies (Whittemore & Knafl 2005, Coughlan et al. 2013). Altogether 11 empirical studies with various study designs were included in the review. The ultimate goal of the integrative literature review was to create an evidence base (Whittemore & Knafl 2005) for the further development of the CLES+T scale (Saarikoski et al. 2008) and the MCI (Figure 3, Page 47).

In Phase II, descriptive as well as user-centred and one-group post-test designs were used to develop and pilot a novel and complex MCI. A descriptive study design was used to evaluate the item and subscale level content validity of the items developed to the T -subscale of the CLES+T scale (Saarikoski et al. 2008)

(Paper II). The new items were developed to assess the nurse teacher's pedagogical cooperation. To examine the item level and subscale level content validity index (Lynn 1986), two rounds of expert panels were performed, which included eight experts in each round: nurse teachers (n=2), nursing education researchers (n=2), CLES+T experts (n=2) and second-year bachelor's level nursing students (n=2). In the first round, the experts evaluated and scored each item on the T_2 -subscale from two perspectives: (1) relevance and (2) clarity, using a 4-point Likert scale. On the subscale level, the experts evaluated and scored the whole subscale from two perspectives: (1) relevance regarding the nurse teacher's clinical role in supporting the nursing students during the clinical practicum; measured by using a dichotomous (yes/no) scale. In cases of no relevance, a written explanation of why was asked for, and (2) the pedagogical cooperation of nurse teachers with nurse students was measured using a 4-point Likert scale. In addition, experts were allowed to add missing items within domains regarding the nurse teacher's pedagogical cooperation with students and to freely comment on the expert panel form or items if so desired. During the second round, the same experts as in round one (n=8) were asked to review the linguistic expressions of the items and to express their opinions in a free-form way on the items in the new subscale that constructed the developed CLES+T_2 scale.

A one-group post-test pilot study with user-centred design was conducted in 2014 to examine the clinical, procedural and methodological aspects of the MCI for informing the development and conduct of the main randomized controlled trial (RCT) (Giangregirio & Thabane 2015) (Papers II, IV). Second-year bachelor's level nursing students (n=6) and the nurse teacher (n=1) were purposively selected to be representative of those in the target population in the RCT (Giangregirio & Thabane 2015). The nursing students were recruited by the researcher herself from the study UAS. The researcher cooperated as the nurse teacher in the pilot study. The participants used the App for a 5-week clinical practicum conducted according to the curriculum. The pilot study was directed to examine the key uncertainties of the intervention identified during its development (Craig et al. 2013), i.e. the recruitment and App training session procedures, the technical performance of the developed App, App usability and the clarity of the questionnaires – including the outcome measures (NCS, SECP, CLES+T_2, SUS) of the MCI.

In Phase III, a parallel group RCT design (Lesaffre 2008) was used to evaluate the effectiveness of the MCI on the nursing students' clinical learning outcomes (Paper III). RCT represents the 'gold standard' for the evaluation of the effectiveness of an intervention (von Essen 2015, Moore et al. 2015) and for developing a robust evidence base that can be used and applied in practice (Feeley et al. 2009). In addition, mixed methods and one-group post-test design was used

to explore the acceptability of the MCI to support the post-hoc interpretation of the outcomes (Craig et al. 2013, Moore et al. 2015) (Paper IV).

Student sample

Based on the sample size calculations (Paper II, III), 50 nursing students per study group were needed (N=100 participants in total) to show the determined ten-point clinically significant difference in the primary outcome of the RCT measured with the Nurse Competence Scale (NCS) (Meretoja et al. 2004a). The sample size calculations were based on the normality assumptions of the primary outcome (Jull and Aye, 2015) and were conducted by using the greatest standard deviation in the study with a student sample by Kajander-Unkuri et al. (2014) and with a statistical power of 80% and a significance level of 0.05 (two-tailed). A convenience sample of nursing student participants (N=118) for the MCI was identified by the researcher herself using both the student group lists from the study UAS and the national employment service database for clinical practicum periods, Jobstep.net (www.jobstep.net) (Figure 4, Page 54), which is Jobiili (www.jobiili.fi) nowadays. Students were enrolled to participate in the study by the researcher herself at the study UAS in the pre-orientation lesson of the clinical practicum in December 2014 and after that by face-to-face conversations or phone calls until the target sample size necessary for achieving the study objectives was reached.

Nursing students who satisfied the inclusion criteria (n=102) were randomly allocated by the researcher herself to the intervention group, IG (n=52) and the control group, CG (n=50) via random permuted block randomisation and a 1:1 allocation ratio to ensure baseline equivalence (Jull & Aye 2015, Lamb & Altman 2015) between the groups (Figure 4). The allocation was implemented by the researcher herself by assigning randomisation codes to the students' signed informed consent forms. To ensure allocation concealment (Jull & Aye 2015), the researcher and students were unaware of the next allocation (Lamb & Altman 2015). The researcher compared the randomisation codes with the computer-generated randomisation lists in order to define the student level allocation at a later date. The researcher herself informed the students about their allocation by sending them an email two weeks before the study.

At the baseline, 102 students were included in the study (Figure 4). The study groups were considered comparable. There were no significant differences in the demographic characteristics between the study groups (IG and CG) (Paper III). The students' mean (SD) age was 23.7 (SD 4.4), ranging from 20 to 38 years. Of the 102 students, 94 (92%) were female. Thus, the sample was considered representative. Student gender and age distribution were rather similar to the Finnish and European nursing students in general (Saarikoski et al. 2013). The majority (n=99, 97%) owned a smartphone, but less than half had a tablet computer

(n=38, 37%), which is similar to the general population in Finland (Statistic Finland 2015). Altogether 98% (n=51) of the students in the IG (n=51) attended the intervention procedures throughout the study and 98% (n=49) of the students in the CG attended the standard cooperation (Paper III, Figure 1).

Mentor sample

A purposive sample of mentor participants was identified based on participating students' clinical practicum placements in the wards across the study hospitals. The researcher herself contacted the ward level key mentors by email to inform them about the study and to obtain the contact details of potential mentors. The potential mentor participants were those who were assigned to be responsible for the supervision of a student who satisfied the inclusion criteria of the study. Mentors were enrolled during ward visits by the researcher herself at the beginning of the students' clinical practicum until all students participating in the study had a mentor willing to participate. The participating mentors were divided into either the IG or the CG based on the student allocated.

At baseline, 102 mentors were included in the study. There were no significant differences in the mentors' demographic characteristics between the study groups (IG and CG) (Appendix 2). The mean age of the mentors was 38.6 (SD 11.2). The majority of the mentors were female (n=95, 93%). A typical mentor had over nine years of experience (range 0–42 years) of student supervision and had supervised three students during the previous year. The researcher also had the role of nurse teacher in the MCI.
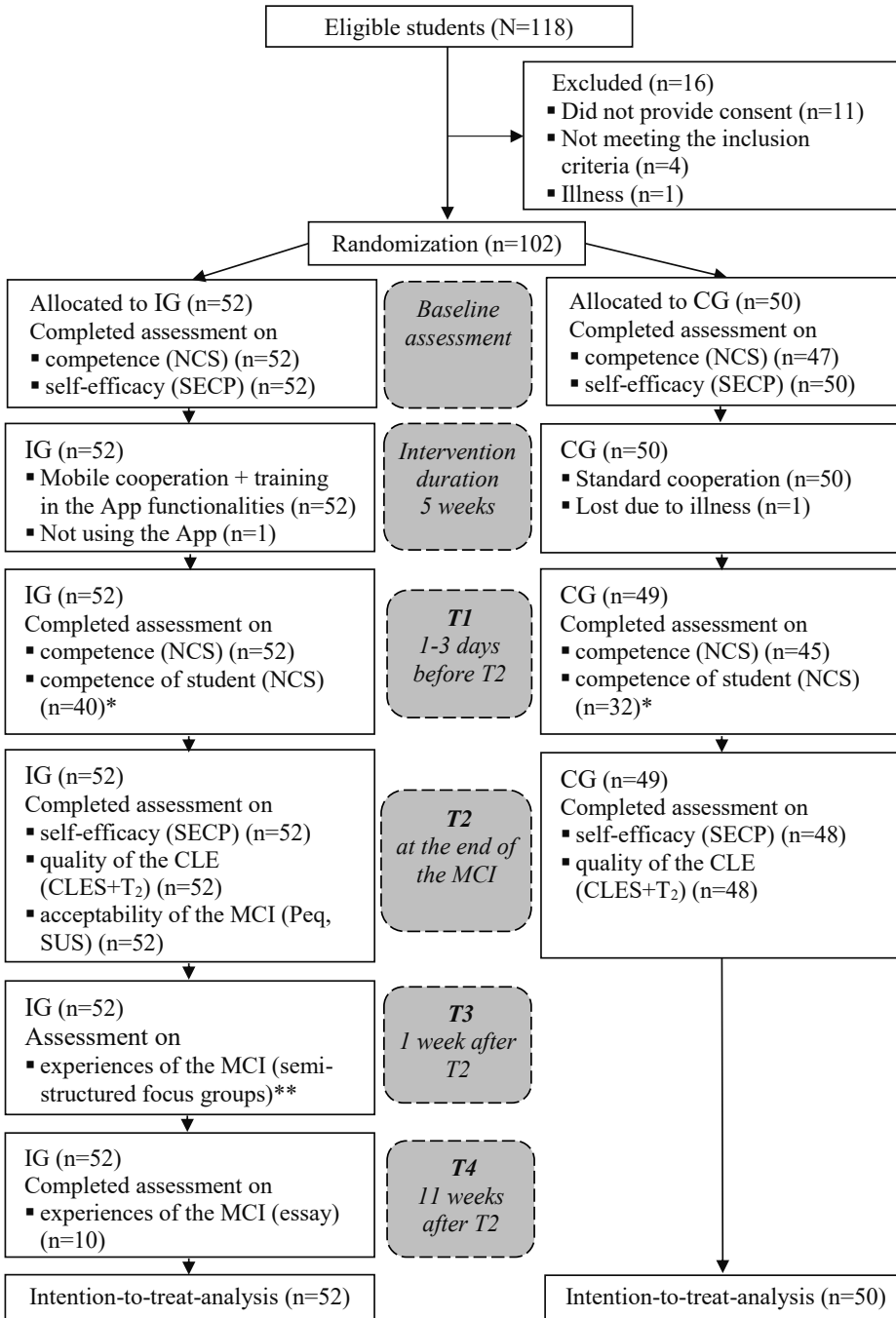
*mentors; ** not analyzed or reported in Papers I-IV or Summary.*

Figure 4. Student and mentor participant flowchart through the study.
(Modified Strandell-Laine et al. 2018, Paper III).

The MCI took place across seven hospitals of one hospital district in Southern Finland. The hospital district, where approximately 1500 nursing student clinical practicum periods are conducted annually, was chosen because of the attempt to standardise the clinical learning environments of nursing students during the MCI. At the time of the study, the hospital districts applied standard procedures when using one-to-one mentor supervision model for all nursing students participating in the study and had a longstanding and extensive mentor training programme. The practicum ward specific CLES+T register data collected from the hospital district in year 2014 showed the same trend with a high overall mean CLES score across all the practicum wards selected for this study. In addition, the hospital district took advantage of the national quality recommendations in student supervision (PSSHP 2010).

The MCI was conducted as part of the nursing students' degree studies and according to the study UAS's nursing curriculum. It took place during the nursing students' surgical and internal medicine clinical practicum periods, providing an authentic context for the clinical practice settings. These settings included 42 inpatient and outpatient surgical and internal medicine wards and related specialty and subspecialty wards that provide extensive specialised healthcare services.

The surgical and internal medicine clinical practicum periods were chosen, because these represent the second and third clinical practicum periods in the nursing curriculum of the study UAS and have the same challenges regarding nursing student–nurse teacher cooperation as the rest of the clinical practicum periods in the nursing curricula. The first clinical practicum was excluded from the study because nursing students' expectations for cooperation with the nurse teacher were reported to be special and extensive compared to the later clinical practicum periods (Brown et al. 2005, Cooper et al. 2015, Levett-Jones et al. 2015). In addition, by excluding the first clinical practicum, it ensured that participants had prior experience of the standard nursing student–nurse teacher cooperation used in the study UAS.

5.2   Standard cooperation and mobile cooperation intervention

Standard cooperation

In this study, *standard cooperation* refers to the nursing student–nurse teacher cooperation representing the standard clinical practicum procedures conducted in the study UAS. Throughout the clinical practicum the nursing students used paper-based practicum documentation to schedule the clinical practicum shifts, learning

objectives, learning diary, mid-point and final evaluations. Emails were used for voluntary individual or group support and communication between student(s) and teacher. The compulsory part of the standard cooperation was that the students could send emails for the nurse teacher about their individual learning objectives and mid-point self-evaluation and their assigned mentor's evaluations for receiving the nurse teacher's feedback on those. Throughout the clinical practicum, the nurse teacher's support regarding the integration of theory and practice and the students' professional development was mainly dependent on the student's own initiative in sending emails to the nurse teacher.

Mobile cooperation intervention

The mobile cooperation intervention (MCI) was developed to facilitate cooperation between nursing students and the nurse teacher and to improve nursing students' clinical learning outcomes.

The MCI was developed by the researcher herself for this study and follows The United Kingdom's Medical Research Council (MRC) guidance for developing and evaluating complex interventions (Craig et al. 2013) (Paper II). The MCI is based on a broad framework comprising the evidence base found in the previous studies (Phase I), standard guidelines in the delivery and conduct of the clinical practicum of the study UAS and study hospital district as well as the national and international regulatory demands (Directive 2005/36/EC, PKSSK 2011, Directive 2013/55/EU, UAS Act 932/2014).

The mobile cooperation intervention was complex and included several interactive components (Craig et al. 2013, Richards 2015). The intervention was conducted in multiple settings across 42 wards, several intervention procedures were provided by both mentors and a nurse teacher (the researcher herself) and the several outcome measures were assessed at different timepoints in different settings (Craig et al. 2013, Richards 2015) (Figure 6, Page 60). The MCI was conducted in a similar way over three practicum periods of five weeks according to the nursing students' curriculum for spring term 2015 in Southern Finland.

The MCI included *nursing student–nurse teacher mobile cooperation* which refers to the use of a mobile device and the App (Study@Campus[Pro]) developed for this study. The mobile application development was guided by the framework of the Mobile Application Development Lifecycle Model (MADLC) by Vithani and Kumar (2014) (Paper IV). The mobile application development is seen as a cycle with several phases and it was conducted in collaboration with a Finnish software company focusing on student and learning management systems and with nursing students (n=6), who represent technology literate users, who can give their views on the optimal format of the mobile application. The mobile cooperation

procedures were equivalent to standard cooperation, but were conducted via the App (Table 7, Figure 5).

Table 7. Procedures for mobile cooperation and standard cooperation.
(Modified from Strandell-Laine et al. 2016, Paper II).

Standard cooperation	Week(s)	Mobile cooperation
Student writes individual learning objectives on the paper-based evaluation form and sends an email about the objectives to the nurse teacher**	*1* *Individual learning objectives*	Student writes individual learning objectives in the App*
Student writes the schedule of shifts on the paper-based form and gives it to the nurse teacher at the post-orientation lecture at the UAS***	*1–5* *Schedule of shifts*	Student writes the schedule of shifts in the App*
Student writes a voluntary learning diary on the paper-based notebook and gives it to the nurse teacher at the post-orientation lecture at the UAS***	*Learning diary*	Student writes a voluntary learning diary in the App*
Voluntary communication with nurse teacher and/or peers via email*	*Communication*	Voluntary communication with NT and/or peers via App*
Student sends individual mid-point evaluation to the nurse teacher by email** Mentor writes student's mid-point evaluation on the paper-based evaluation form and student sends an email about the mentor's evaluation to the nurse teacher **	*3–4* *Mid-point evaluation*	Student types individual mid-point evaluation to the App* Mentor types student's mid-point evaluation to the App*
Student writes individual final evaluation on the paper-based evaluation form and gives it to the nurse teacher at the post-orientation lecture at the UAS***	*5* *Final evaluation*	Student writes individual final evaluation in the App*
Mentor writes student's final evaluation on the paper-based evaluation form and student gives it to the nurse teacher at the post-orientation lecture at the UAS***		Mentor writes student's final evaluation in the App*
Mentor sends an email on the student's overall evaluation (pass/fail) to the nurse teacher**		Mentor writes student's overall evaluation (pass/fail) in the App*

*Immediate nursing student–nurse teacher cooperation is possible
**The nursing student–nurse teacher cooperation is possible after the email has been sent
***The nursing student–nurse teacher cooperation is possible after the clinical practicum at the UAS

The App works with iOS and Android software, enabling broad usage on the students' own mobile devices in the MCI. The App includes elements for (1) documentation and managing the schedule of clinical practicum shifts, a voluntary learning diary, learning objectives as well as a mid-point and final evaluation of

the clinical practicum; as well as (2) support and communication between students, nurse teacher and mentors by means of exchanging individual or group messages with each other (Figure 5). All actions in the App are automatically saved and shared between the student, mentor and teacher, and they have the opportunity for both synchronous and asynchronous cooperation during the clinical practicum shifts and outside of the clinical practicum.
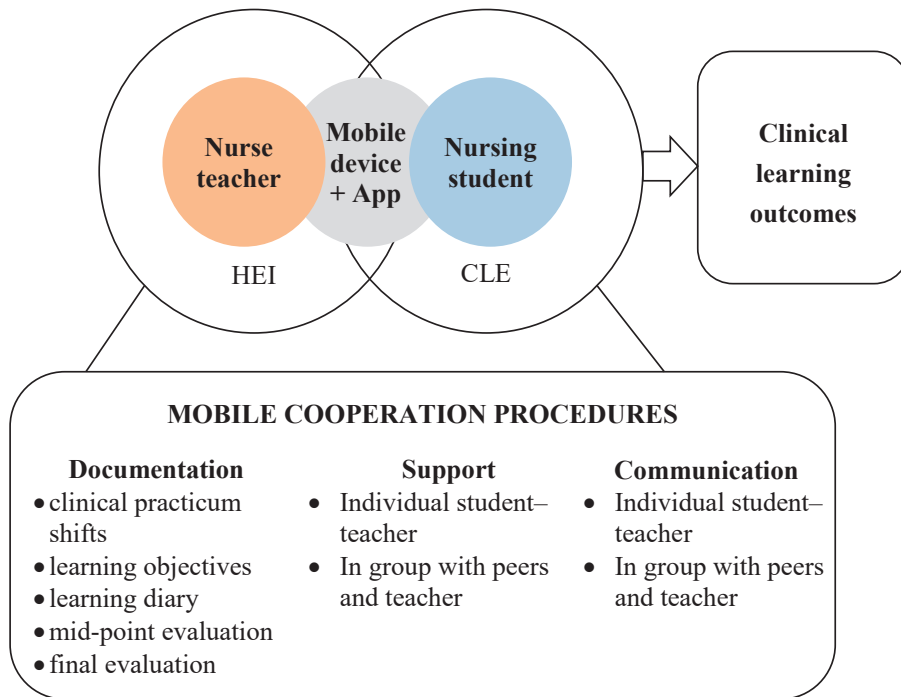

Figure 5. Mobile cooperation procedures in the App.
HEI = higher education institution; CLE = clinical learning environment

5.3   Data collection and instruments

In Phase I, the data were collected by undertaking an integrative literature review. The data were gathered from the systematic and comprehensive electronic search performed in March 2014 on four electronic databases: PubMed/Medline, CINAHL, PsycINFO and ERIC, which was then supplemented by a footnote search of reference lists and authors (Kable et al. 2012) (Paper I). The database search was limited to English language articles but with no limitations of the study design or time limits, thus a comprehensive view of the subject area was gained.

In this summary, the search was updated with an identical strategy covering the years 2014–July 2018.

In Phase II, the data for evaluating the content validity of the T_2-subscale of the CLES+T_2 scale were collected between October–December 2014 via two rounds of expert panels with different versions (T_1, T_2) of the T-subscale assessing the nurse teacher's pedagogical cooperation with students. The members of the expert panel participated in both expert panels and included teachers (n=2), nursing education researchers (n=2), CLES+T experts (n=2) and second-year pre-registration nursing students (n=2). The data for the pilot study of the MCI were collected through the researcher's observations and experiences of the student recruitment and App training sessions and in face-to-face meetings with the nursing students (n=6) via paper-based structured questionnaires at the study UAS in November 2014 after the students had used the App for five weeks. The questionnaire included socio-demographics, NCS, SECP, CLES+T_2 and Peq. In addition, during the face-to-face meeting, students were asked to freely comment on the technical performance of the App and the experiences of the MCI.

In Phase III, the data for evaluating the effectiveness and process of the MCI were collected from January to May 2015. The data collection comprised the outcome variables of the primary outcome (competence), two secondary outcomes (self-efficacy and quality of the CLE), the process evaluation and the register data. In addition, socio-demographic data were collected from students and mentors in both study groups. The data were collected from the students in the IG and CG via paper-based questionnaires in hospital settings at three time points (Baseline, T1 and T2) and from mentors at one timepoint (T1). In addition, the data were collected from the IG for conducting the process evaluation at two timepoints using semi-structured focus group interviews (T3) and essays (T4) at the study UAS (Figure 6).
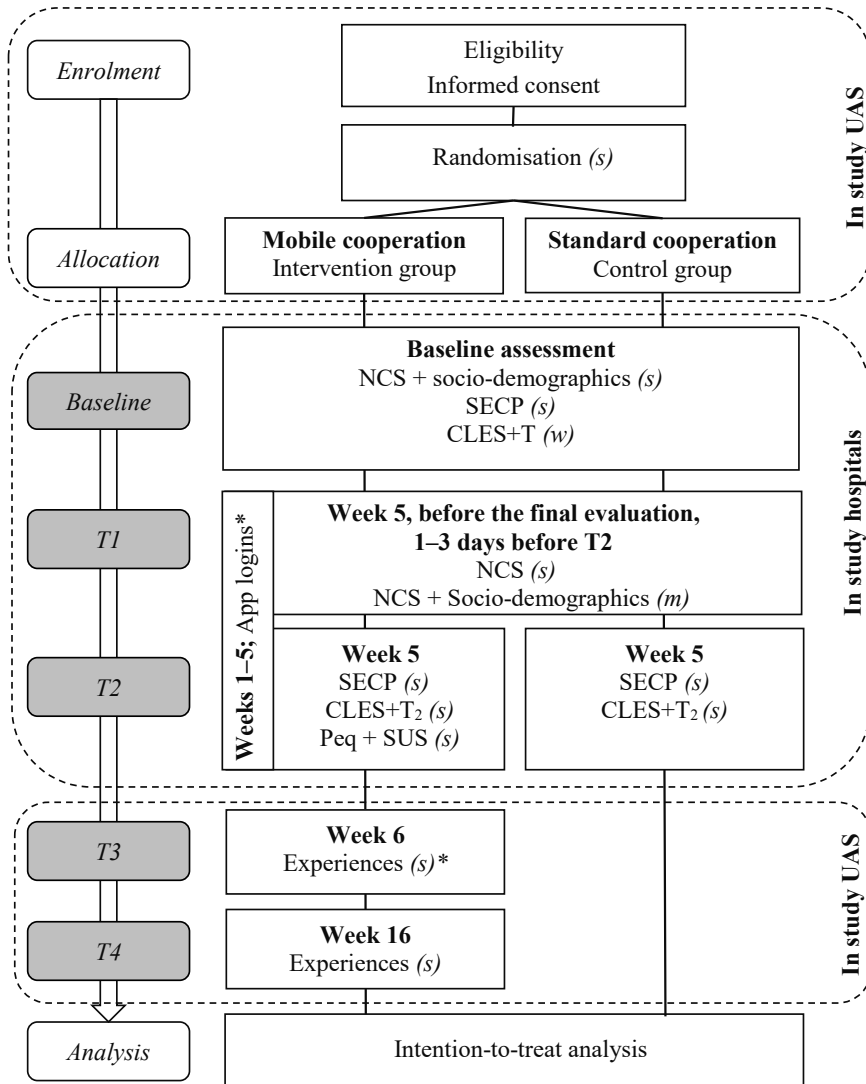
Enrolment

Eligibility
Informed consent

Randomisation *(s)*

Allocation

Mobile cooperation
Intervention group

Standard cooperation
Control group

In study UAS

Baseline

Baseline assessment
NCS + socio-demographics *(s)*
SECP *(s)*
CLES+T *(w)*

T1

**Week 5, before the final evaluation,
1–3 days before T2**
NCS *(s)*
NCS + Socio-demographics *(m)*

T2

Weeks 1–5; App logins*

Week 5
SECP *(s)*
CLES+T$_2$ *(s)*
Peq + SUS *(s)*

Week 5
SECP *(s)*
CLES+T$_2$ *(s)*

In study hospitals

T3

Week 6
Experiences *(s)**

T4

Week 16
Experiences *(s)*

In study UAS

Analysis

Intention-to-treat analysis

Figure 6. Data collection in Phase III.

*(m)=mentors; (s)=students; (w)= ward specific register data 2014; *will be reported later, not reported in Papers 1-IV or in the Summary*

Instruments

Various instruments were used in Phase III to evaluate the effectiveness and acceptability of the mobile cooperation intervention (Table 8).

Table 8. Outcome variables and instruments used by the study group in Phase III in this study.

Instrument	Outcome variable	Items	Subscales	Study groups	Scale
CLES+T	Quality of the CLE	34	*Quality of the CLE in:* I Pedagogical atmosphere II Leadership style of the ward manager III Supervisory relationship IV Role of the nurse teacher	IG, CG	Likert 1–10 *Totally disagree– Totally Agree*
	Background variables (students)	25	Socio-demographics Education Ongoing nursing degree studies Upcoming clinical practicum View of the nursing profession Mobile device use and attitudes	IG, CG	Variations between items: Dichotomous and Likert scale
	Background variables (mentors)	17	Socio-demographics Education Work experience as RN Work experience as mentor View of the nursing education	IG, CG	Dichotomous and Likert
NCS	Competence (primary outcome)	73	*Competence in:* I Helping role II Teaching–coaching III Diagnostic functions IV Managing situations V Therapeutic interventions VI Ensuring quality VII work role	IG, CG	VAS 0–100 *Very low-level– Very high-level AND* Likert 0–3 *Not applicable– very often*
SECP	Self-efficacy (secondary outcome)	37	*Self-efficacy in:* I Assessment II Diagnosis and planning III Implementation IV Evaluation	IG, CG	Likert 0–10 *Totally disagree– Totally Agree*
CLES+T_2[*]	Quality of the CLE (secondary outcome)	39	*Quality of the CLE in :* I Pedagogical atmosphere II Leadership style of the ward manager III Supervisory relationship IV Role of the nurse teacher	IG, CG	Likert 1–10 *Totally disagree– Totally Agree*
SUS	Usability of the App	10	Learnability of the App Usability of the App	IG	Likert 1–5 *Totally disagree– Totally Agree*
Peq	Acceptability	12	Commitment to the MCI Experiences of the MCI	IG	Dichotomous

Further developed for this study

The Nurse Competence Scale (NCS) has been developed in Finland by Meretoja et al. (2004) to assess nurses' generic competence. The NCS comprises 73 items on seven competence subscales: helping role, teaching–coaching, diagnostic functions, managing situations, therapeutic interventions, ensuring quality and the work role. The level of each competency item is assessed with a Visual Analog Scale (VAS), which ranges from 0 to 100 mm, (0=very low-level competence; 100=very high-level competence). In addition, the frequency with which each competence item is used is assessed via a four-point Likert scale (0=not applicable; 1=very seldom; 2=occasionally; 3=very often). (Table 8.) For descriptive purposes, the VAS is divided into four parts to represent the level of competence: "low competence" (0–25), "quite good competence" (>25–50), "good competence" (>50–75) or "good competence" (>75–100) (Meretoja et al. 2004a). The NCS has been validated nationally and internationally and it has been proven to be sensitive in differentiating competence levels in various clinical settings among nursing students (Kajander-Unkuri et al. 2014) and between the students and mentors' assessments (Kajander-Unkuri et al. 2015). According to Flinkman et al. (2017), the NCS is the most widely used instrument for assessing the generic competence of nurses.

The Self-Efficacy in Clinical Performance instrument (SECP) was developed in Iran by Cheraghi et al. (2009) to assess the beliefs of nursing students regarding their ability to succeed during the performance of their clinical performance. The SECP was double translated for this study, from the English version into Finnish using the back-translation method (Sousa & Rojjanasnirat 2011) by qualified English teachers. In addition, one nursing student from the UAS, whose mother tongue is Persian, reviewed and approved the congruence between the Finnish translation and the original Persian version (Table 6, Page 50). The SECP comprises 37 items, with four subscales: assessment, diagnosis and planning, implementation, and evaluation. Self-efficacy was assessed with an eleven-point Likert scale (0=totally disagree; 10=totally agree). (Table 8.)The SECP has been validated with Iranian student populations and it has been proven to be valuable for student self-assessment (Cheraghi et al. 2009).

The Clinical Learning Environment, Supervision and Nurse Teacher scale (CLES+T scale) was developed in Finland (Saarikoski 2002, Saarikoski et al. 2008) to assess the quality of the clinical learning environment as experienced by nursing students. The CLES+T scale was further developed in this study with regard to the T -subscale to assess the nurse teacher's pedagogical cooperation with students. The new subscale was developed based on existing international literature and the researcher's multi-dimensional and long experience as a qualified nurse teacher in the context of supervising nursing students during the clinical practicum. The developed CLES+T_2 scale comprises 39 items and has four

subscales: pedagogical atmosphere, the leadership style of the ward manager, supervisory relationship and the role of the nurse teacher, including the five new items developed in this study. The quality of the clinical learning environment was assessed with a ten-point Likert scale (1 totally disagree; 10=totally agree). (Table 8.) The CLES+T scale is a widely used and validated instrument in various clinical settings among nursing students both in Finland and internationally (Mueller 2018). Moreover, the instrument has been validated in primary healthcare settings (Bos et al. 2012) and used in an explorative comparative validation study involving Belgium, Cyprus, Finland, Italy, Spain, Sweden, The Netherlands and the UK (Warne et al. 2010).

The System Usability Scale (SUS) was developed in United States by Brooke (1996, 2013) to assess how end-users perceive the general usability of a wide range of technologies (Bangor et al. 2008, Sauro 2011). In this study, the Finnish version of SUS was used (Jokela 2018). The technology agnostic (Bangor et al. 2008) scale is based on three usability criteria as specified by ISO 9241-11: (1) effectiveness, i.e. the ability of users to finish tasks using the system and the quality of the output of tasks; (2) efficiency, i.e. the level of effort and resources used to complete tasks; and (3) satisfaction, i.e. the users' subjective experience when using the system (Borsci et al. 2009). SUS comprises 10 items that assess the users' perceptions of the usability (8 items) and learnability (2 items) of the technology. Usability and learnability are assessed by a five-point Likert scale (1=totally disagree; 5=totally agree) (Table 8). SUS provides a single overall SUS score ranging from 0 to 100 (0=worst usability: 100=best usability) in which a score of 68 represents the average SUS score (Brooke 2013).

5.4   Data analyses

In this study, data analysis methods consisted of critical appraisal, thematic and content analysis, content validity index as well as statistical analyses, including descriptive analysis and statistical modelling (Table 5, Page 49). In this chapter, data analyses are described according to the study Phases I–III.

In Phase I, in the integrative literature review, the included studies (n=11) were thematically analysed (Miles & Huberman 1994, Whittemore & Knafl 2005, Braun & Clarke 2006). The thematic analysis method was chosen because it offers flexibility in analysing the qualitative data independent of the theoretical and epistemological approaches. It was also regarded as a suitable method for reflecting the experiences, meaning and reality of the mobile device end-users (Braun & Clarke 2006). There is no gold standard for the critical appraisal of the studies (Whittemore & Knafl 2005). In this study, the critical appraisal was

conducted using standardised study design-specific checklists: CONSORT 2010 Statement (Moher et al. 2012), TREND Statement (Des Jarlais et al. 2004) and STROBE Statement (von Elm et al. 2007). The thematic analysis and the critical appraisal of the studies were conducted by the researcher herself in collaboration with one other researcher for validity purposes. (Paper I.)

In Phase II, the content validity of the five new items of the CLES+T$_2$ scale was explored. The item-level and subscale-level content validity of the expert panels were calculated following the criteria by Lynn (1986). The item-level content validity index (I-CVI) was calculated by summing up the experts' ratings concerning the item relevance with either three or four and by dividing according to the total number of expert counts. The subscale level content validity index (S-CVI) was calculated by summing up the I-CVI and by dividing according to the number of items (Polit & Beck 2006). Second, the data from open-ended question were analysed by inductive content analysis. Cronbach's alpha was used to evaluate the internal consistency of the instruments (McColl et al. 2006). (Paper II.)

In Phase III, both statistical analyses (Paper III, IV) and a qualitative data analysis (Paper IV) were conducted. In relation to the NCS, the data were gathered both from nursing student and mentor participants. The analyses reported in this chapter include only student participants if case mentors are not mentioned. Statistical analyses were conducted both in relation to the evaluation of the intervention effectiveness and the process evaluation of the intervention. The statistical analyses are described in connection with the outcome variables.

Statistical analyses were carried out using an intention-to-treat approach, i.e. all participants randomised in the study were included in the analysis. For all analyses, the statistical significance was set at a two-tailed *p*-value of 0.05 (Mosteller et al. 2006, Berben et al. 2012). The statistical analyses were performed with SAS® software for Windows (version 9.4, SAS Institute Inc., Cary, NC, USA) and the IBM SPSS Statistics® for Windows software (version 23.0 or later, IBM Corp., Armonk, NY, USA). Categorical data were described by frequencies and proportions, and continuous data were described by mean and standard deviation (SD) when normally distributed and by median, range and upper (Q$_1$) and lower (Q$_3$) quartiles in cases of non-normal distribution. Cronbach's alpha was used to evaluate the internal consistency of the instruments used in this study.

The baseline socio-demographic characteristics of the nursing students were compared between the study groups (IG, CG) using a two-sample t-test (normally distributed continuous variables), the Wilcoxon rank sum test (continuous non-normal variables), a Chi-square test or Fisher's exact test (categorical variables),

depending on the nature of the variable. Comparisons between mentor groups (IG, CG) were conducted with the same methods of analysis.

If more than 25% of the answers in competence (subscale or total) were missing, the derived mean values were also declared missing. *The overall competence* was analysed using hierarchical linear mixed models for repeated measures. The Kenward-Roger correction was used for degrees of freedom and compound symmetry was used for the covariance structure. The final model, which includes the whole study population, time (baseline, T1) and group by time interaction, tested whether the mean changes were different between the groups. In addition, age group (20–24 years, 25–30 years, and 31–38 years) and age group by time interaction were added to this model. Moreover, gender, previous healthcare education, the students' self-assessed adequacy regarding their theoretical knowledge before the clinical practicum (theoretical knowledge), the self-assessed adequacy of the students' practical skills before the clinical practicum (practical skills), the students' sense of fear at the beginning of the clinical practicum (also time interaction) were included in the initial model but were tested and removed from the final model as they were all shown to be non-significant. While this method can include all data available no imputing for missing values was done. The differences between the mean of the student and mentor were analysed using a paired *t*-test at T1 because the data were normally distributed.

The overall self-efficacy was analysed in a similar way to overall competence and all non-significant explanatory variables were removed from the model. The final model included study group, time (baseline, T2) and group by time interaction. Within the model, 95% confidence intervals were calculated to estimate the mean changes for both study groups and each age group. The normality assumption was checked with studentised residuals.

The overall satisfaction with the CLE was more or less normally distributed and the multi-way analysis of variance with the model, including group, theoretical knowledge and practical skills was tested and all non-significant explanatory variables (gender, previous healthcare education, prior working experience in social and healthcare) were removed. Satisfaction with the CLE was measured only at the end of the MCI, after the final evaluation of the clinical practicum (T2) and comparisons between the intervention group and the control group were made by using the Mann-Whitney U-test as many of the subscale distributions were shown to be skewed.

Associations between outcome variables (competence, self-efficacy and quality of the CLE) were evaluated at T2 using two-way analysis of covariance, where the model included the group as a categorical explanatory variable and the corresponding sub-scores as a numerical explanatory variable.

The SUS items were scored before the analysis by a system developed by Brooke (1996, 2013), leading to a new item contribution ranging from 0 (the most negative response) to 4 (the most positive response). The mean SUS score comparisons between the categories of the different explanatory variables were conducted by a Kruskal-Wallis test continued with Steel-Dwass multiple comparisons.

The Qualitative data analysis was conducted independently by two researchers and it was based on the data gathered in the process evaluation. The s*tudents' experiences of using the MCI* were gathered from the student essays and were analysed by an inductive approach using thematic analysis (Braun & Clarke 2006), performed independently by two researchers. First, to familiarise themselves with the data, the data were read and re-read by the researchers. Second, the initial codes of the data were identified and grouped into sub-themes on a potential thematic map. After this, the themes were reviewed and the final names for the themes were generated. The analysis of the essays led to the identification of nine sub-themes and two main themes.

5.5   Ethical considerations

The principles of research ethics and good scientific practice were followed throughout the whole research process (National Advisory Board on Social Welfare and Health Care Ethics, ETENE 2006, WHO 2011, the Finnish Advisory Board on Research Integrity TENK 2012, World Medical Association, WMA 2013, All European Academies, ALLEA 2017).

This study is acceptable from an ethical perspective because the topic, aims and the ultimate goal of this study are significant for the field of the nursing education research from two viewpoints. First, this study meets the need to extend the rigorous evidence base regarding the potential of emerging mobile technologies in the clinical learning of nursing students (O'Connor & Edwards 2015, Strandell-Laine et al. 2015 [Paper I]). Second, the clinical practicum is a vital component of a nursing student's degree studies, enabling the improvement of competence and self-efficacy, thus it has inevitable consequences for their future nursing career, especially in the quality and safety of the patient care they provide (Aiken et al. 2011, 2014) and their likelihood to leave the nursing workforce (van Waeyenberg et al. 2015). Hence, the effectiveness of novel educational interventions in improving essential and expected clinical learning outcomes must be examined.

In Phase I, the integrative literature review comprised existing empirical evidence and no permissions were needed. The expertise of the information specialist was used in the systematic database searches. The thematic analysis and critical

appraisal of the included studies were performed independently by two researchers and added to the consensus discussions to ensure reliable inclusion, review, extraction, coding and appraisal.

The study protocol, for *Phases II and III*, received ethical approval by the Ethics Committee of the University of Turku (15.12.2014, Statement 45/2014). Special attention was given to documentation that describes how the RCT is conducted: The RCT is listed in the public registry ClinicalTrials.gov by the identifier NCT02635295 and its study protocol has been published in a peer-review journal (Paper II).

Permission to conduct the RCT was obtained from the participating organisations and from the study UAS (22.11.2014) for Phases II and III and from the study hospital district (5.12.2014, T257/10/0.12.14) for Phase III. Permission to use the original NCS, to use and modify the CLES+T scale as well as to translate the SECP instrument were received from the copyright holders. Permission to use the App was given by the software company that owns the intellectual property rights for the designed user interface, including: exclusive right to produced source code, machine language architecture of the software and graphical user interface.

Students were the main study participants in the pilot study in Phase II and in the RCT in Phase III. They were not considered particularly vulnerable because they were over 18 years old and voluntarily undertaking nursing education and capable of giving informed consent. However, when conducting nursing education research, ethical challenges are faced if students are used as participants, especially regarding the voluntariness of the participation (Ferguson et al. 2006, Bradbury-Jones & Alock 2010, Loftin et al. 2011). This was carefully considered at all phases of this study.

First, the study was conducted during the compulsory clinical practicum undertaken by the students, thus students may have felt coerced into participation. Nevertheless, students in both groups conducted the clinical practicum with similar curriculum objectives and procedures and nothing that could have had an effect on their grades was offered to students. The decision to participate or decline was kept confidential (Loftin et al. 2011) by assigning all students to the same nurse teacher, irrespective of whether they participated in the study or not. Second, the dual roles of the researcher and nurse teacher may have created role conflict during the study (Ferguson et al. 2004, Bradbury-Jones & Alcock 2010, Loftin et al. 2011). However, in this study the nurse teacher had no previous pedagogical relationship with the eligible students to be recruited and met them for the first time at the recruitment meeting at the pre-orientation lesson of the clinical practicum. Thus, it was considered that the students did not feel an imbalance in their relationship with the researcher and thus felt free to either decline or accept participation.

The use of the App was believed to cause minor inconvenience for the students in the IG. Students had to spend time taking an App functionality training session and had to use the App during the five week clinical practicum. This may have caused stress for the students. However, in recent studies, the students have reported a high motivation to use mobile technology in the clinical practicum (Doyle et al. 2014, Strandell-Laine et al. 2015 [Paper I]). According to previous studies, student technology literacy varies extensively (Strandell-Laine et al. 2015 [Paper I]), therefore students assigned to the IG were provided with subsequent technical support and/or training in the App functionalities during this study to ensure the full use of the App in the cooperation procedures. In addition, students were offered the possibility to load the App into their own mobile devices due to the high prevalence of smartphone ownership among Finnish students (Suominen et al. 2014). However, students were also provided with the possibility to borrow an iPad from the study UAS. This enabled participation in the study in spite of non-ownership of a mobile device or the technical features of the student's own mobile device. Data collection was conducted by face-to-face student–researcher meetings at the study UAS in Phase II and in study hospitals in Phase III when it was convenient for students during clinical practicum shifts.

Students were informed in Phases II and III by an information letter and by face-to-face meetings about the purpose of the study, and voluntary participation; the assurance of anonymity and confidentiality was made by the researcher herself. Students were informed about their right to withdraw from the study at any point without any negative repercussions for the completion of their studies. Written informed consent forms were signed by students before start of the pilot study in Phase II and before the random allocation to the study groups in Phase III. Students who did not give their consent or withdrew from the study, conducted their clinical practicum according to the curriculum in cooperation with the same nurse teacher to guarantee the continuity of the teaching relationship after the pre-orientation lesson of the clinical practicum. To assure all eligible and voluntary students' full participation in the RCT, the enrolment process to find mentors continued until all participating nursing students had a mentor willing to participate.

During the researcher's visits to the wards in Phase III, mentors were informed through information letters and by face-to-face meetings about the purpose of the study, voluntary participation, the assurance of anonymity and confidentiality. Mentors were informed about their right to withdraw from the study at any point without any negative repercussions for them. Written informed consent forms were signed by mentors after the random allocation of the students to the study groups. For mentors, participation in this study was considered a minor harm as they had to use time to participate in the training session for the use of the App, but this was arranged at the wards and when convenient during their work shifts. In addition,

mentors had to use time to complete the structured questionnaire on socio-demographics and the NCS, which were used to assess the competence of the students they supervised. It was reported that the time needed to complete the NCS assessment ranges from 20 to 30 minutes (Dellai et al. 2009, Kawther et al. 2011) and mentors had the right to do this as part of their student supervision procedures during their working shifts. Participation in this study was not considered a benefit for the mentors, their own participation may have been seen as benefiting nursing students (Bradbury-Jones et al. 2011) and therefore themselves in the future.

The confidentiality of the student and mentor participants was guaranteed by saving the informed consent forms (with the direct participant identifiers) and the student–mentor pair re-identifiable screening codes separately from the study records and in a space locked by the researcher. The personal data of the students and mentors in IG that were collected for creating individual usernames for the App, were stored and protected according to good research practices regulated by the Finnish Personal Data Act (1999/523). To protect the confidentiality of both participants and patients in the students' practicum wards, the App was password protected. Direct access to the identifiable data in the App was guaranteed for the software company in case there were unethical practices conducted with the App by the participants. The paper-based questionnaires were stored in a locked space by the researcher and the App's login and electronic data were secured with a password-protected access system. The research data were stored in the university server by the researcher.

6   RESULTS

In this chapter, the main results regarding the three outcome measures and process evaluation of the MCI are summarised according to the research questions and hypotheses. A more comprehensive and precise reporting of the results is described in the original Papers I, III and IV. This summary includes previously unpublished findings, which are reported in this chapter in more detail. The results of the original and updated integrative review on the use of mobile devices in nursing student–nurse teacher cooperation during the clinical practicum are described in more detail in Chapter 3.3, which provides the evidence base (Figure 3, Page 47) for the empirical study.

6.1   Mobile device use in nursing student–nurse teacher cooperation during the clinical practicum

The systematic literature search was performed to identify previous empirical studies on mobile device use in nursing student–nurse teacher cooperation during the clinical practicum. A total of 11 studies were included in the original integrative review (Paper I). As a result of the updating of the original literature review, the final integrative review in the Summary comprises 17 studies. The results are reported in Chapter 3.3 as part of the literature review and in detail in Paper I.

The mobile devices have been used for several purposes in the clinical practicum, but have had other main purposes, like information retrieval, instead of cooperation between nursing student and nurse teacher. However, the use of mobile devices in the clinical practicum does seem to provide benefits for the nursing student–nurse teacher cooperation (Paper I, Summary.)

Various learning technology solutions have been used to enhance the student–nurse teacher cooperation. Nevertheless, any mobile application specifically developed for the student–nurse teacher cooperation was identified (Table 4, Pages 42–43). Moreover, methodological weaknesses in the quality of the studies were identified (Paper I, Summary, Appendix 1).

6.2 Clinical learning outcomes in the mobile cooperation intervention

In this chapter, the results of the mobile cooperation intervention (MCI) are presented. The effectiveness of the MCI was examined by evaluating whether the MCI assisted nursing student–nurse teacher cooperation had an effect on nursing students' clinical learning outcomes, i.e. individual outcomes (competence or self-efficacy) or contextual outcomes (the quality of the clinical learning environment). The MCI is described in detail in Chapter 5.2, Papers II and III, and the clinical learning outcomes in Chapter 3.2.

6.2.1 Individual outcomes of the intervention

In this chapter, the results of the MCI regarding the individual outcomes (competence and self-efficacy) are presented.

Students' self-assessed competence (Paper III, Summary)

Students' self-assessed competence was measured at the baseline and at the end of the MCI, before the final evaluation of the clinical practicum (T1) (Figure 4, 6). Students assessed their competence by using the Nurse Competence Scale (NCS, Meretoja et al. 2004a) to evaluate whether the MCI had an effect on nursing students' competence (Table 8).

At the baseline, the students' self-assessed overall mean competence was measured at 38.5 (SD 16.1) in the IG and 40.9 (SD 17.3) in the CG. When the competence scores were compared numerically, the difference between the IG and CG was 2.2 (95% CI -5.1 to 9.5), but non-significant ($p=0.56$). At T1, the students' self-assessed overall mean competence was 45.6 (SD 18.2) in the IG and 49.2 (SD 21.8) in the CG. When the competence scores were compared numerically, the mean difference between the IG and CG was 3.72 (95% CI -3.6 to 11.1), but non-significant ($p=0.32$). (Figure 7, Table 9, [Paper III; Table 2].)

On the subscale level, the highest mean competence of the students' self-assessments was observed in the "helping role" subscale in both study groups at T1. The lowest mean competence in the students' self-assessments was observed in the "therapeutic interventions" subscale in both study groups at T1 (Figure 9, Table 9, [Paper III; Table 2]).
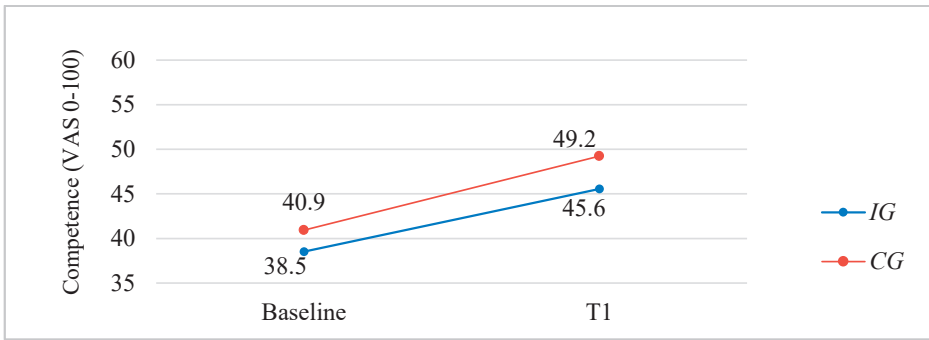
Figure 7. Students' self-assessed overall mean competence by the study groups at baseline and T1.

The competence improvement in the overall mean competence was measured over the intervention period (5 weeks), from the baseline to the T1. The competence improvement was significant in both groups ($p<0.001$) in favour of the CG, which showed an improvement of 11.7 (95% CI 7.1 to 16.3) compared to 10.1 (95% CI 5.7 to 14.5) for the IG. However, the improvement between the IG and CG was non-significant ($p=0.57$). On the subscale level, all subscales showed a significant improvement (all $p<0.014$) in both groups, except for the subscale 'ensuring quality' ($p=0.14$) (Figure 8, [Paper III; Table 2].)
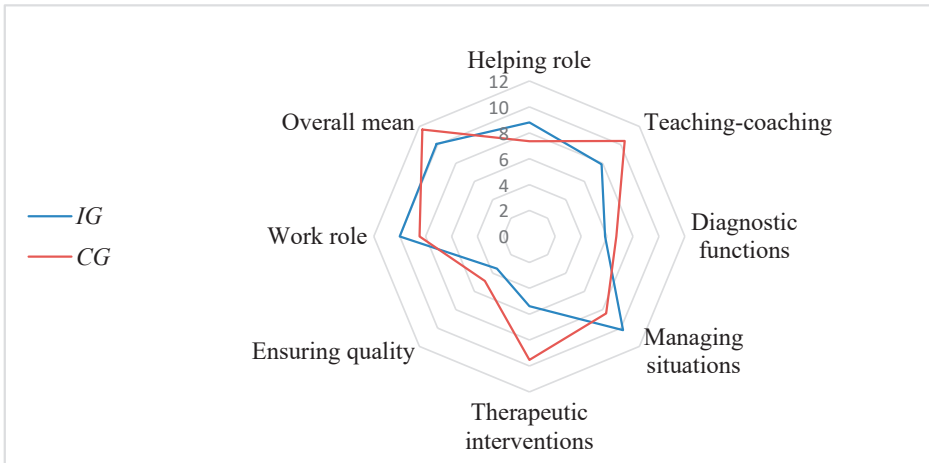
Figure 8. The mean improvement in the students' self-assessed competence by the study groups over the intervention period.

The congruence between the nursing students' self-assessments and the mentors' assessments of the students' competence (Summary)

The congruence between the nursing students' self-assessed competence and the mentors' assessment of the nursing students' competence was examined at the end of the MCI, before the final evaluation of the clinical practicum (T1). Both the nursing students' self-assessment and the mentors' assessment of the students' competence were made on the Nurse Competence Scale (NCS, Meretoja et al. 2004a) (Figure 4, 6, Table 8).

At T1, the mentors assessed the students' overall competence as being 42.7 (SD 22.0) in the IG and 43.4 (SD 23.4) in the CG, with non-significant group difference (p=0.90). When the competence scores were compared numerically, the difference between the assessment of the students and the mentors was 4.4 (95% CI -4.5 to 13.3) in the IG and 6.6 (95% CI -2.2 to 15.3) in the CG. The between-group differences (students and mentors) in the IG (p=0.32) and in the CG (p=0.14) were non-significant. There was a non-significant correlation in the IG (r=0.053, p=0.744) but a significant moderate positive correlation in the CG (r=0.45, p=0.012) between the student and mentor assessments with the NCS at T1.

At the subscale level, the students' highest competence in the mentors' assessments was observed in the "helping role" subscale in both study groups and was 50.7 (SD 20.3) in the IG and 47.5 (SD 23.6) in the CG, with non-significant group-difference (p=0.51). The students' lowest competence in the mentors' assessments was observed in the "therapeutic interventions" subscale with the groups at 34.6 (SD 23.8) in the IG and 30.4 (SD 24.7) in the CG, with non-significant group difference (p=0.56) (Table 9).

At T1, the level of the students' competence, was assessed by dividing the students' self-assessed and the mentors' assessment of the students' overall mean competence scores into four parts (0–25, >25–50, >50–75, >75–100) (Chapter 5.3, Page 62, Meretoja et al. 2004a). Less than half of the students in both study groups (45%, n=44) assessed themselves as having a 'quite good competence' level (VAS scores >25–50), 54% in the IG (n=28) and 36% in the CG (n=16) and 10% of the students in both groups (n=10) assessed themselves as having a 'very good competence" level (VAS scores >75–100), 10% in the in IG (n=5) and 11% in the CG (n=5). Less than half of the mentors (36%, n=26) assessed their own student as having a "quite good competence" level (VAS scores >25–50) and 10 % of the mentors (n=7) assessed their student as having a 'very good competence" level (VAS scores >75–100). (Figure 9, Table 9.)
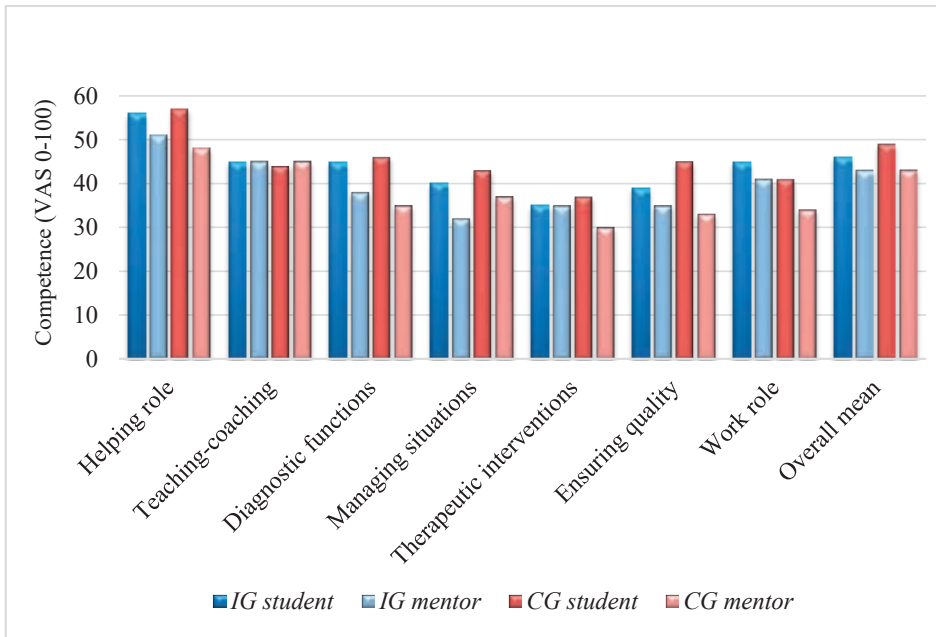
Figure 9. Student and mentor assessment of the competence on the overall mean and subscale level by the study groups at T1.

Table 9. Student and mentor assessment of the students' competence at T1.

Subscale	Students			Mentors			Student–mentor difference			
	IG Mean (SD) Range	CG Mean (SD) Range	p Group	IG Mean (SD) Range	CG Mean (SD) Range	p Group	IG Mean (SD) 95% CI	p Diff.	CG Mean(SD) 95% CI	p Diff.
Helping role	56.47 (13.98) 14.00–83.50	57.24 (18.71) 16.86–91.17	0.74	50.65 (20.26) 6.14–91.67	47.52 (23.59) 1.29–81.60	0.51	6.60 (26.48) -1.26 to 14.46	0.08	10.52(27.02) 1.87 to 19.16	0.018*
Teaching-coaching	45.38 (17.81) 2.56–68.63	44.05 (22.40) 8.94–86.13	0.78	45.47 (23.21) 6.19–91.42	44.56 (22.35) 0.44–77.94	0.87	0.15(25.86) -8.47 to 8.77	0.97	3.16(24.46) -6.72 to 13.04	0.52
Diagnostic functions	45.04 (18.44) 5.86–89.00	45.75 (24.43) 10.86–89.75	0.42	38.09 (25.80) 1.29–97.67	35.19 (22.12) 1.14–75.33	0.67	9.94 (30.21) -0.60 to 20.48	0.064	13.05 (27.00) -0.38 to 26.48	0.056
Managing situations	40.01 (20.44) 2.38–74.40	43.10 (23.21) 3.25–80.00	0.48	32.20 (24.25) 0.63–87.60	36.71 (25.70) 0.00–82.00	0.51	13.17 (28.43) 1.17 to 25.18	0.032*	10.82 (21.04) 0.68 to 20.97	0.038*
Therapeutic interventions	35.09 (18.62) 2.50–69.40	36.88 (23.55) 4.00–79.00	0.34	34.62 (23.76) 1.30–91.67	30.37 (24.65) 0.00–75.29	0.56	3.54 (27.86) -7.26 to 14.35	0.51	2.72 (21.05) -12.33 to17.78	0.69
Ensuring quality	38.82 (21.74) 7.00–79.67	45.30 (22.61) 2.33–86.00	0.22	34.60 (24.11) 0.00–10.50	33.30 (23.86) 0.00–87.67	0.83	7.54 (36.68) -5.68 to 20.77	0.25	13.81 (26.30) 2.71 to 24.92	0.017*
Work role	44.81 (21.37) 5.84–74.71	40.92 (20.73) 6.63–80.64	0.71	41.41 (24.69) 1.63–88.46	34.06 (22.48) 0.00–73.08	0.30	3.94 (31.28) -7.74 to 15.62	0.50	1.37 (17.85) -13.55 to 16.30	0.83
Overall mean	45.55 (18.15) 14.84–82.41	49.23 (21.79) 8.05–85.56	0.27	42.74 (21.96) 2.81–87.05	43.40 (23.37) 0.33–81.49	0.90	4.41 (27.81) -4.48 to 13.30	0.32	6.56 (23.41) -2.18 to 15.30	0.14

Group p-value indicates whether there is a significant difference between IG and CG. Diff. p-value indicates whether there is a difference between students and mentors in the study group. Number of subjects varied between the subscales, IG_s=44–52, CG_s=36–49, IG_m=28–46, CG_m=17–40; s= student, m=mentor. *p<0.05.

Self-efficacy (Paper III, Summary)

The self-efficacy of the students was assessed by themselves at the baseline and at the end of the MCI, after the final evaluation of the clinical practicum (T2) (Figure 4, 6). The self-efficacy was assessed by the students with the Self-Efficacy in Clinical Performance instrument (SECP, Cheraghi et al. 2009), which helps evaluate whether the MCI has had an effect on the self-efficacy of the nursing students (Table 8).

At the baseline, the self-assessed overall mean self-efficacy was 5.2 (SD 1.6) in the IG and 5.4 (SD 1.5) in the CG. When the self-efficacy was compared numerically, the difference between the IG and CG was 0.2 (95% CI -0.4 to 0.8), but non-significant *(p=0.56)*. At T2, the students' self-assessed overall mean self-efficacy was 7.0 (SD 1.2) in the IG and 6.9 (SD 1.6) in the CG. When the self-efficacy scores were compared numerically, the difference between the IG and CG was 0.1 (95% CI -0.5 to 0.7, *p=0.78*), but non-significant. (Figure 10, [Paper III; Table 3].)
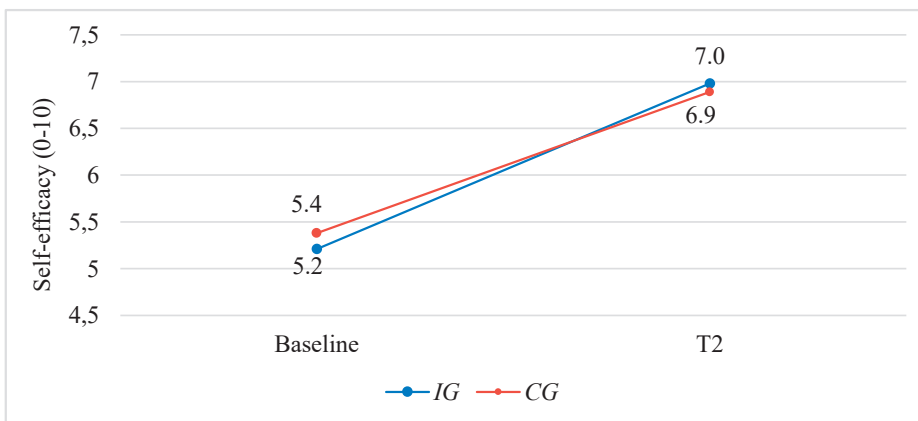
Figure 10. Students' self-assessed overall mean self-efficacy by the study groups at baseline and T2.

The self-efficacy improvement in the overall mean self-efficacy was measured over the intervention period (5 weeks) from the baseline to T2. The self-efficacy improvement was significant in both groups (*p<0.001*) in favour of the IG with an improvement of 1.8 (95% CI 1.4 to 2.2) compared to 1.5 (95% CI 1.1 to 1.9) in the CG. However, the improvement between the IG and CG was non-significant (*p=0.37*). On the subscale level, all subscales showed a significant improvement (*p<0.001*) in both groups. (Figure 11, [Paper III; Table 3].)
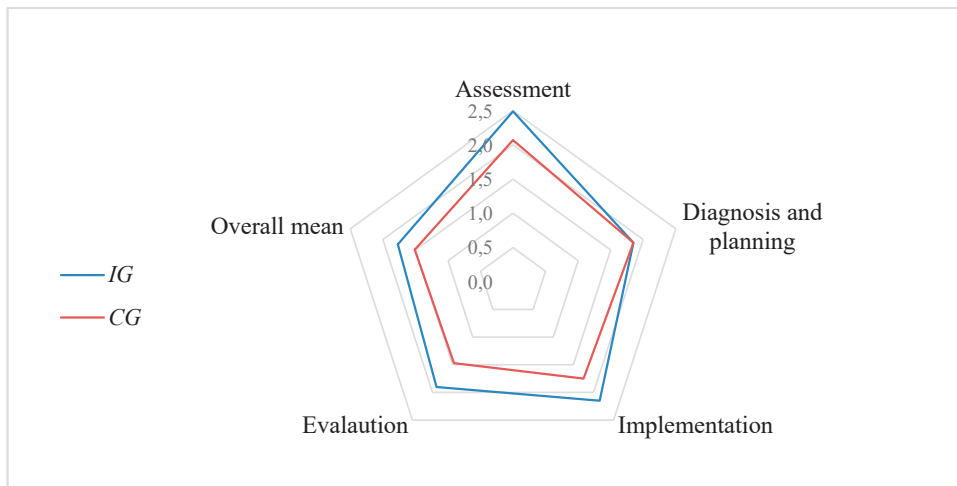
Figure 11. The mean improvement in the students' self-assessed self-efficacy by the study groups over the intervention period.

6.2.2 Contextual outcomes of the intervention

In this chapter, the results of the MCI regarding the contextual outcomes (quality of the clinical learning environment) are presented.

Quality of the clinical learning environment (Paper III, Summary)

The quality of the clinical learning environment (CLE) as experienced by the students was assessed at the end of the MCI after the final evaluation of the clinical practicum (T2) (Figure 4, 6). The quality of the CLE was assessed by the students with the further developed Clinical Learning Environment, Supervision and Nurse Teacher scale, CLES+T_2 scale to evaluate whether the MCI had an effect on the quality of the CLE as experienced by the nursing students (Table 8). On the T - subscale, the role of the nurse teacher was further developed to assess the quality of the nurse teachers' pedagogical cooperation with the students as experienced by them. This development is described in Chapters 5.1, 5.3 and 7.2.1 as well as in Paper II.

The overall mean of the quality of the CLE was evaluated by using the mean scores of all the responses regarding the CLES+T_2 items. At T2, the overall mean quality of the CLE as experienced by the students was 7.81 (Q_1 7.0, Q_3 8.4, SD 1.3) in the IG and 7.53 (Q_1 6.6, Q_3 8.3, SD 1.1) in the CG, with a non-significant group difference (p=0.24). However, on the subscale level, a significant difference was found between the IG and CG regarding the "role of the nurse teacher" subscale

and in "the premises of the nursing on the ward" subscales (all $p<0.033$) (Figure 12, 13, [Paper III; Table 4]).
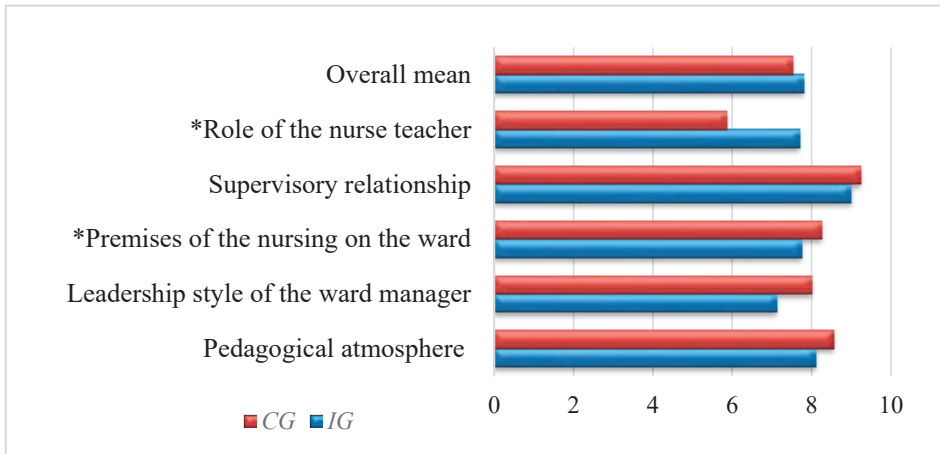

Figure 12. The quality of the CLE as experienced by the students in the study groups at T2.
Number of subjects varied between sub-dimensions: IG (n=52), CG (n=47–48).
*indicates that there is a significant difference between the study groups (p<0.05).

A new T_2-subscale called "nurse teachers' pedagogical cooperation with students" was developed in this study for the CLES+T scale and was used for the first time with a nursing student sample in the MCI. Therefore, the results of this new subscale are reported in more detail on the subscale and item level in this summary.

The quality of the nurse teachers' pedagogical cooperation with the students as experienced by them was significantly higher in the IG (median 8.8; Q_1 7.6, Q_3 9.6) than in the CG (median 7.9; Q_1 6.3, Q_3 9.0) ($p=0.026$). On the item level of this subscale, the IG was significantly more satisfied with the nurse teacher's role in promoting students learning (median 9.0; Q_1 9.0, Q_3 10.0) than the CG (median 8.0; Q_1 8.0, Q_3 9.3) ($p=0.043$) and with regard to the nurse teacher's role in helping to relieve stress (median 8.0; Q_1 8.0, Q_3 9.0) than it was with the CG (median 7.0; Q_1 7.0, Q_3 8.5) ($p=0.024$) (Figure 13, Appendix 3, Paper III).
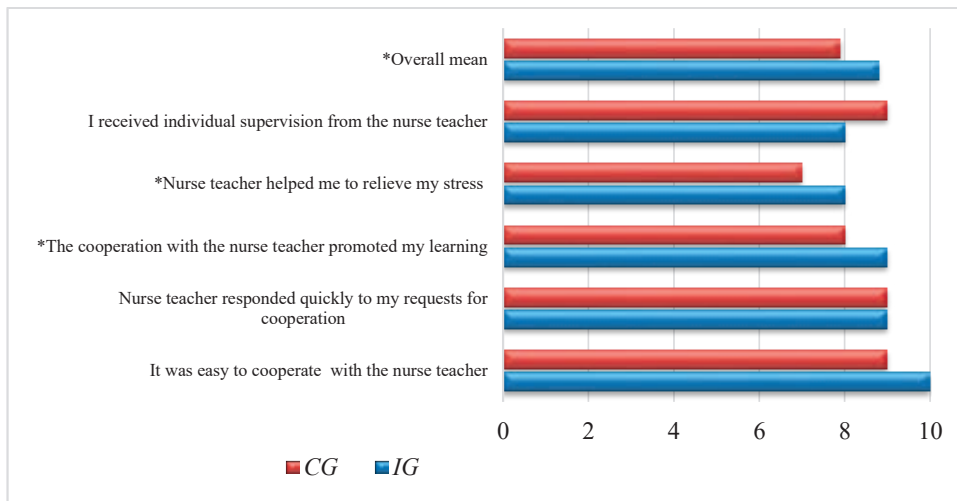
Figure 13. Nurse teacher's pedagogical cooperation with the students by the study groups at T2.

indicates that there is a significant difference between the study groups (p<0.05).

6.2.3 Factors associated with the clinical learning outcomes in the intervention

First, while studying which factors are associated with an improvement in the clinical learning outcomes over the intervention period, univariate approach was applied in other words all factors were tested one by one. Only significant factors were left into the final model. Therefore, results of significant background variables, competence, self-efficacy and quality of CLE are reported.

Explanatory factors associated with improvement in the clinical learning outcomes (Paper III, Summary)

The student age group was the only explanatory factor significantly associated with an improvement in the overall competence of the whole study population that was assessed by the NCS. Students in the oldest age group (31–38 years) showed a significantly greater improvement ($p=0.035$) in their overall mean competence compared to the youngest age group of students (20–24 years).

The self-reported lower theoretical knowledge ($p=0.024$) and practical skills ($p=0.019$) of the students at the baseline were significantly associated with lower overall satisfaction with the CLE.

The students' self-assessed competence showed the same trend regarding the self-assessed frequency of use of the items of competence with respect to both the overall mean competence and the subscale level trend of the whole study population (Figure 14). The higher the students assessed their competence, the higher their reported frequency in using the respective competence.
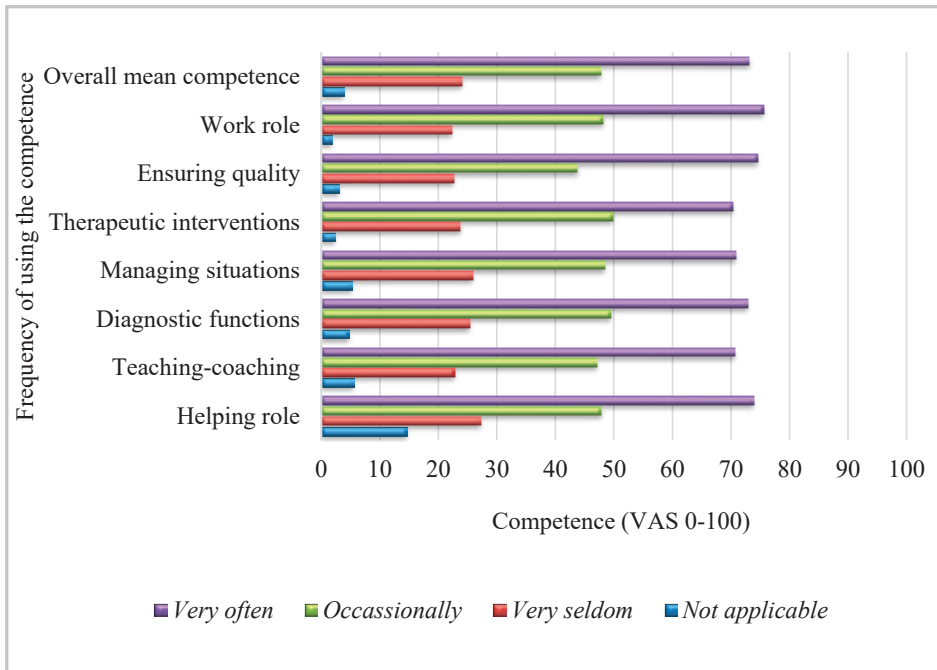

Figure 14. Relation between students' self-assessed competence scores and the frequency of use of the competence in both the overall mean competence and in the subscales at T1.

Associations between the clinical learning outcomes as assessed by the students after the MCI (Paper III, Summary)

A significant moderate positive correlation between the overall mean competence and overall mean self-efficacy of the whole study population was detected at baseline ($r=0.65$, $p<0.0001$) and after the MCI, at T2 ($r=0.46$, $p<0.0001$). The scatterplots (Figure 15) illustrate these correlations between the overall mean competence and the overall mean self-efficacy at the baseline and after the MCI, at T2 (Figure 15, Paper III). Each point in the scatterplot represents the mean competence and mean self-efficacy as assessed by the students themselves.
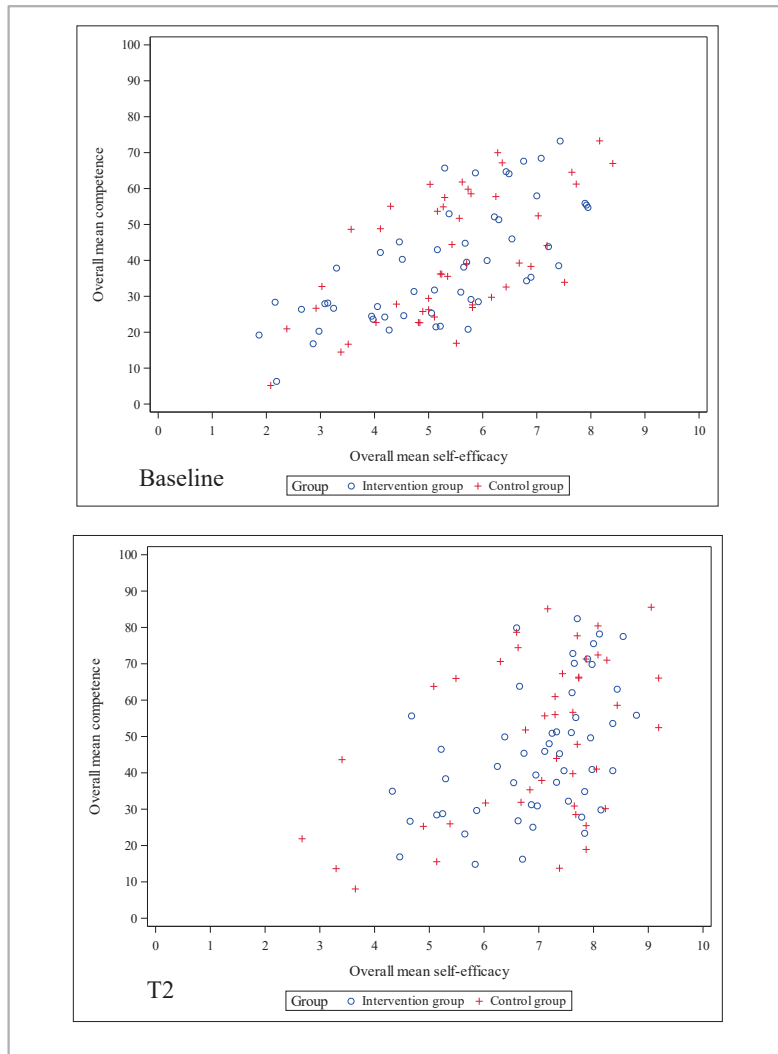
Figure 15. Scatterplot for the correlations between the NCS and SECP according to study group at the baseline and at T2.

6.3 Acceptability of the mobile cooperation intervention

In this chapter, the main results of the process evaluation of the MCI are reported from the perspectives of the nursing students in the IG, which represents the intervention recipients. A more detailed description of the results of the process evaluation can be found in Paper IV. The process evaluation was conducted by evaluating the acceptability of the MCI at two timepoints (T2, T4) by exploring the students' commitment to and experiences of using the MCI. First, the acceptability of the MCI was assessed using a process evaluation questionnaire

(Peq) developed for this study that included structured questions of the commitment to and experiences of the MCI and the System usability Scale, SUS (Brooke 1996, 2003). Second, students' experiences of the MCI was assessed by students' essays, which were written 11 weeks after the end of the MCI at T4. (Figure 4, 6, Table 8.) In this chapter, the nursing students' acceptability of the MCI is reported according to the nursing students' commitment to and experiences of using the MCI.

Commitment to the MCI (Paper IV)

The commitment of the students to the MCI was high in terms of active App use during the practicum hours in the ward (n=48, 92%) and outside the practicum hours at home (n=49, 94%). Over half (56%) of the students (n=29) used the App several times a week and 29% (n=15) used it when needed. Altogether 25% of the students (n=13) used a borrowed iPad from the study UAS, because of the small screen size of their own devices. One student (2%) refused to use the App when completing the cooperation procedures during the MCI (Paper IV, Table 4).

Experiences of the MCI (Paper IV)

In relation to the usability of the App, the perceived usability of the App was assessed by the students after the intervention with the System Usability Scale (SUS, Brooke 1996) by the students (n=52) in the IG. The usability of the App showed a mean SUS score of 69.9 (SD 19.9, range 10.0–97.5) out of a possible 100 (Table 10, Paper IV). The mean SUS scores were significantly higher among those students who held positive experiences from the App functionality training given at the baseline ($p=0.017$) and their App usage during the intervention ($p<0.001$) (Paper IV, Table 4). Moreover, the mean SUS scores were significantly higher among students with positive experiences of the utility of the App with regard to time saving and its ubiquitous use in practicum procedures (all $p<0.047$) (Paper IV, Table 6).

Table 10. The perceived usability of the App as assessed by the students (n=52), scale 0 (most negative response) to 4 (most positive response) (Modified from Strandell-Laine et al. submitted)

SUS items	Mean (SD)
Usability	
I think that I would like to use this App frequently	2.50 (1.26)
I found this App to be simple	2.85 (1.09)
I thought this App was easy to use	2.87 (1.16)
I found the various functions in this App were well integrated	2.38 (1.09)
I thought there was a lot of consistency in this App	2.79 (1.09)
I would imagine that most people would learn to use this App very quickly	3.04 (0.99)
I found this App very intuitive	2.79 (1.30)
I felt very confident using this App	2.58 (0.98)
Learnability	
I think that I could use the App without the support of a technical person	3.10 (1.21)
I could use the App without having to learn anything new	3.06 (1.11)
The SUS score	69.86 (19.89)

Student experiences with the MCI were also examined by means of student essays. The analysis of the essays revealed two main themes: the usability of the App (Figure 16) and the utility of the App (Figure 17). In relation to the usability of the App, both success and difficulty regarding the App's ease of use and its learnability were reported. In addition, in several essays, satisfaction with using the App and a willingness to use it in the future were reported. The App was seen as a positive innovation for nursing education. (Figure 16, [Paper IV, Figure 1].)
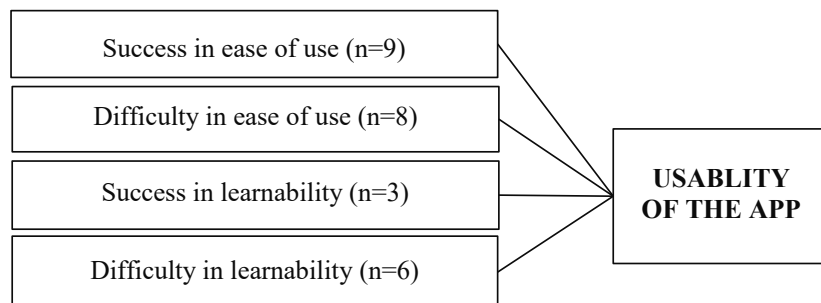

Figure 16. The experienced usability of the App in the MCI. (Modified from Strandell-Laine et al. submitted, Paper IV)

In relation to the utility of the App, it facilitated the students' self-directed learning and the nursing student–nurse teacher cooperation i.e. communication between the nursing student and nurse teacher and the practicum documentation and

convenience in it. However, the App was reported also as being a hindrance to practicum procedures (Figure 17, [Paper IV, Figure 1]).
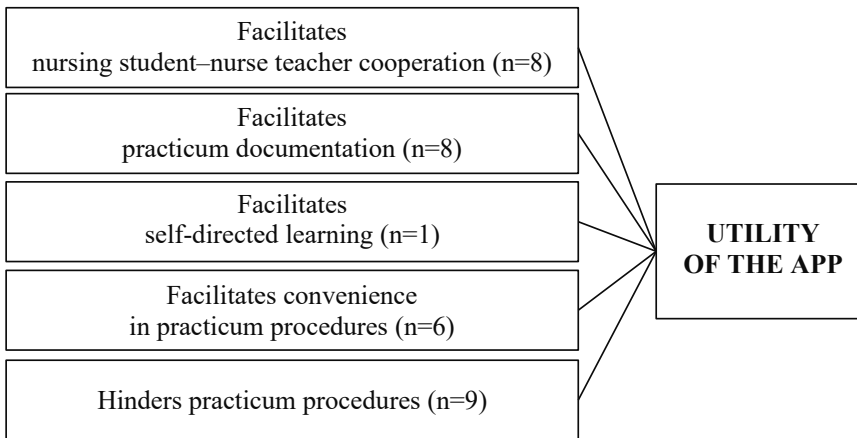
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┌─────────────────────────────────────┐
│              Facilitates            │
│ nursing student–nurse teacher cooperation (n=8) │
├─────────────────────────────────────┤
│              Facilitates            │
│     practicum documentation (n=8)   │
├─────────────────────────────────────┤          ┌──────────────┐
│              Facilitates            │          │   UTILITY    │
│     self-directed learning (n=1)    │          │ OF THE APP   │
├─────────────────────────────────────┤          └──────────────┘
│        Facilitates convenience      │
│     in practicum procedures (n=6)   │
├─────────────────────────────────────┤
│   Hinders practicum procedures (n=9)│
└─────────────────────────────────────┘
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Figure 17. The experienced utility of the App in the MCI. (Modified from Strandell-Laine et al. submitted, Paper IV)

6.4   Summary of the main results

Based on the results of the integrative review, mobile device use in the nursing student–nurse teacher cooperation during the clinical practicum has become more prevalent during recent years, although it is still an emerging area in nursing education. The use of mobile devices varies greatly in the previous studies due to different mobile devices as well as the purposes and durations of use. However, in most of the studies one software was used in the nursing student–nurse teacher cooperation. The purpose of the mobile device's use was usually not to facilitate the nursing student–nurse teacher cooperation but to support nursing students at the bedside of patients and for private purposes. Thus, no mobile application purposively designed for nursing student–nurse teacher cooperation was found. The quality of the identified studies varies and it is not possible to draw firm conclusions from the results. The previous studies mainly report the nursing students' views, representing one end-user group of the mobile devices and mobile applications. However, the students seemed satisfied, motivated and willing to use mobile technology in their nursing degree studies, especially in the clinical practicum.

The novel and complex mobile cooperation intervention, developed in this study, showed no significant intervention effect regarding individual or contextual outcomes. In relation to individual outcomes, student competence and self-efficacy improved significantly in both study groups, with non-significant group-differences. In relation to contextual outcomes, students in the intervention group that used the App to cooperate with the nurse teacher showed significantly higher satisfaction with the quality of the nurse teacher's clinical role, especially regarding nurse teacher pedagogical cooperation with students (Figure 18). In the whole study population, an older age predicted a significantly greater improvement in their competence during the five weeks. In addition, the students' own views regarding better theoretical knowledge and practical skills before the mobile cooperation intervention predicted significantly higher student satisfaction with the CLE after the intervention. No explanatory factor explained the intervention effect.

The students' acceptability of the MCI was high, though there were minor challenges with the technology literacy of the students and Wi-Fi connectivity in the study hospitals. The App was experienced as easy to learn and easy to use among the nursing students. In addition, students reported feelings of connectivity, nurse teacher availability and the ability to achieve their aims when using the App.
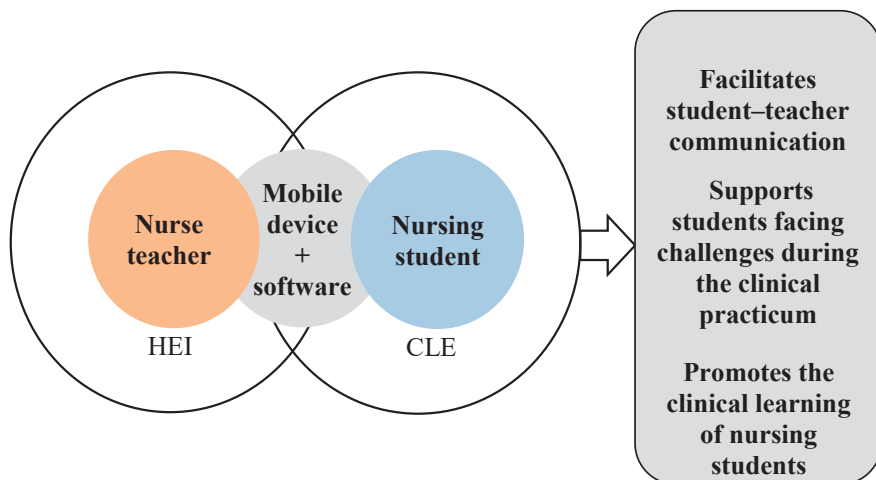

Figure 18. Summary of the results of the study.
*HEI = higher education institution; CLE = clinical learning environment

7   DISCUSSION

In this discussion, the main results of this study are discussed in the light of prior study findings and then followed by a discussion on the validity and reliability of the study. In addition, suggestions for future research and practical implications are stated. More detailed discussions are presented in papers I, III and IV.

7.1   Discussion of the results

In this study, a novel nursing student–nurse teacher mobile cooperation intervention, MCI, was developed to facilitate nursing student–nurse teacher cooperation during the clinical practicum. The effectiveness and acceptability of the MCI were evaluated in a RCT study with nursing students as intervention recipients. The ultimate goal of this study is to improve the quality of nursing education and consequently the outcomes of patient care. To reach the purposes and the ultimate goal of this study, three study phases were conducted.

Previous studies on mobile cooperation during the clinical practicum

The results of the original and updated reviews (Phase I, III) reveal that the use of mobile technology appears to provide benefits for nursing student–nurse teacher cooperation. However, previous studies have focused more on the nursing students' experiences of the mobile device use than on the effectiveness of mobile devices in improving the clinical learning outcomes of students. Moreover, mobile devices were commonly used for other purposes, e.g. for information retrieval, and not for cooperation with the nurse teacher. No mobile application has been specifically developed for nurse student–nurse teacher cooperation (Phase I, III). The critical appraisal of the studies (Phase I) revealed methodological weaknesses in the quality of the studies, which predominantly produced level II–VI evidence (Polit & Beck 2012). These results (Phase I) are in line with other reviews of the research on the integration of mobile technology into the clinical practicum of nursing students (Ward & Moule 2007, Doyle et al. 2014, Guo et al. 2015, O'Connor & Edwards 2015, Raman 2015). Nevertheless, level II–VI evidence is also needed and it is necessary to develop the evidence base (Polit & Beck 2012), thus forming a solid basis for future studies that have rigorous designs, i.e. randomised controlled trials, representing the "gold standard" for the evaluated effectiveness of a certain intervention (von Essen 2015, Clark et al. 2018).

Since the original integrative review (Phase I) was conducted in 2015, there has been an increasing amount of mobile technology literature published with regard

to nursing education research. At least one new review has been published about the integration of mobile technology into nursing education (Lee et al. 2018b). However, rigorous evidence on the effectiveness of nursing student–nurse teacher mobile cooperation in improving the clinical learning outcomes of nursing students seems to be still lacking. The findings of this review reveal that the amount of studies with RCT design has increased but the quality of these studies is still weak. The results of this study (Phase I, III) confirm the findings of a growing body of literature, which clearly indicates a positive attitude towards and satisfaction with mobile technology use among nursing students and without any intervention effect on student competence. Thus, the results of the recent review (Lee at el. 2018b) are in line with the review findings of this study (Phases I, III) highlighting the need for studies with randomised controlled study designs to produce evidence to inform the development and use of mobile technology in nursing education. In this study, the aim was to provide answers to some of the research gaps identified in the previous studies.

Clinical learning outcomes in MCI

Individual outcomes of MCI

In this study, the individual outcomes were assessed by students themselves at the beginning (baseline) and at the end of the MCI (T1, T2). The hypothesis for the individual outcomes was that the students in the IG would have a significantly greater mean improvement over the intervention period in competence and self-efficacy compared to those in the CG.

The hypothesis was not confirmed as the MCI was shown to be merely equally effective in improving students' individual outcomes as the standard cooperation method; when the self-assessed competence and self-efficacy of the student were considered. However, this is an educationally significant finding, because while competence (ICN 2006, WHO 2009, Yanhua & Watson 2011, Hakimzadeh et al. 2013, Shin et al. 2014, Kajander-Unkuri et al. 2014, 2016, Ličen & Plazar 2015, Kajander-Unkuri et al. 2016) and self-efficacy are stated as major goals and part of the effectiveness criteria of nursing education (Lauder et al. 2008b), even the MCI was not successful in demonstrating effectiveness on the competence and self-efficacy of nursing students. This finding confirms the fact that there is no nursing student–nurse teacher cooperation method superior to any other as highlighted by previous studies (Bloomfield et al. 2008, Saarikoski et al. 2013, Gustafsson et al. 2015a, Forber et al. 2016). However, the MCI can be considered an alternative method for existing nursing student–nurse teacher cooperation methods. In addition, this finding provides a rigorous evidence base for future curricula development in nursing education at a time when urgency is required to develop effective pedagogical methods that have strong technological approaches.

New methods are required in order to respond to both the ongoing digitalisation in society and the recommendations for enhancing higher education through the use of new mobile technologies (EC 2014, Junger 2016, Parviainen et al. 2017).

This study generates new rigorous evidence about the competence level of nursing students during their degree studies. In the previous literature, the use of self-assessments regarding student competence has been criticised because of findings that reveal that mentors assess the competence of their supervised students as slightly lower than the students do (Kajander-Unkuri et al. 2016). This study only partly confirms these findings. In this study, the differences between the mentors' and the students' assessments of the students' competence were shown to be non-significant. Nevertheless, weak congruence between these assessments could be demonstrated and both mentors and students assessed the competence as quite good according to the VAS scores > 25–50 (Flinkman et al. 2017) at the end of the MCI. These findings reveal that students might be capable of self-assessing their competence but may need more support in this assessment from nurse teachers and mentors. It seems, that this support might be possible to give with the aid of the App developed in this study.

In relation to mentors, one reason for the mentors' assessments giving slightly lower competence scores could be the fact that mentors do not have sufficient skills or guidelines with which to assess student competence as was reported in earlier studies (Helminen et al. 2014, 2016, 2017). Thus, assessments made by mentors may be based more on the optimal view of a GNS's competence than students as learners (Burden et al. 2017) because no consensus on either of the levels of competence exists for the different stages of nursing education or at graduation (Blackman et al. 2007, Kajander-Unkuri et al. 2014, Zasadny & Bull 2015). This is an aspect that needs attention and collaboration between mentors and nurse teachers in order to enhance the optimal competence assessments of nursing students. This collaboration might be possible to conduct with the aid the App developed in this study but requires further research.

However, the findings reveal that NCS (Meretoja et al. 2004a) can be applied when assessing nursing students' competence both by students themselves and their mentors during the final evaluation of a clinical practicum, though both seem to require more guidance and support to conduct this assessment. This is an educationally significant finding that has to be considered in the future as competence assessment is a significant component of nursing education (Gallagher & Ousey 2012, Burden et al. 2017) and competence development itself is defined as an expected learning outcome from a clinical practicum period (Watson et al. 2002, Löfmark et al. 2006, Salminen et al. 2010, Directive 2013/55/EU, EFN 2015). Moreover, nursing education relies on self-directed learning (e.g.

Bloomfield et al. 2008, Voutilainen et al. 2017) and the students' self-assessment, which has been stated as being a critical skill for graduated nurses (Baxter & Norman 2011), and thus needs to be developed throughout nursing degree studies. Nursing students' self-assessment by the NCS might provide solutions to this by ensuring the completion of a relevant self-assessment process during nursing studies in the context of the clinical practicum.

Contextual outcomes of MCI

In this study, the contextual outcomes were assessed by students themselves at the end of the MCI. The hypothesis for the contextual outcomes was that the students in the IG have a significantly higher satisfaction with the CLE compared to those in the CG.

The MCI was successful in demonstrating significant effect on nursing students' satisfaction with the nurse teacher role, especially in the nurse teacher's pedagogical cooperation with students, when the quality of the CLE as experienced by the nursing students was considered. This is an educationally significant finding as it responds to the need of nursing student for more nurse teacher support, reported in previous studies (e.g. Mackay & Harding 2009, Saarikoski 2009b, Price et al. 2011, Löfmark et al. 2012, Saarikoski et al. 2013, Foster et al. 2014, Gustafsson et al. 2015, Papastavrou et al. 2016b, Pitkänen et al. 2018), although the MCI was not successful in demonstrating significant effect regarding the quality of the CLE. Nevertheless, the main aim of the nurse teacher' clinical role is to pedagogically support both students (Brown et al. 2005, Price et al. 2011, Killam & Heerschap 2013, Pitkänen et al. 2018) and mentors (Salminen et al. 2013, Helminen et al. 2017, Pitkänen et al. 2018) in the clinical learning of nursing students. Moreover, the nurse teacher is responsible for ensuring that the clinical placement is carried out according to the goals of the degree programme (Warne et al. 2010). To fulfil these tasks, the nurse teacher has to cooperate both with the students and mentors during the clinical practicum (Saarikoski et al. 2008, 2009b) and the developed App might be an appropriate tool for this in the future. This study generates new evidence on the issue of nurse teacher pedagogical cooperation with students as measured by items developed to respond to the clinical role of nurse teachers, a role that is increasingly being conducted via distance cooperation methods (e.g. Saarikoski et al. 2009b, 2013, Mikkonen et al. 2017a).

In this study, two educationally significant factors associated with the contextual outcomes of the MCI were detected. The nursing students' self-assessed pre-practicum theoretical knowledge and pre-practicum practical skills were demonstrated to be significantly associated with satisfaction with the CLE, producing new and educationally significant evidence for nursing curricula

development. This association has not been reported in previous studies. However, this finding reveals the importance of the students' pre-practicum learning, which seems to have an influence on the quality of the CLE as experienced by nursing students. This, may also influence the choice of the future workplace as revealed by previous studies (Flinkman et al. 2017). Nevertheless, this connection was not the focus of this study but it should be examined in the future.

Acceptability of the MCI

This study (Phase I, III) confirms nursing students' positive attitudes towards and high interest in using mobile devices in nursing student–nurse teacher cooperation – as revealed by previous studies (Guo et al. 2015, O'Connor & Andrews 2015, Raman 2015). There is high prevalence for using mobile devices among nursing students internationally (e.g. Williamson 2018) and in Finland (Statistics Finland 2017) and that finding is also revealed in this study (Phase III). The high ownership of mobile devices might explain the positive attitude among nursing students as they regard mobile technologies as part of their daily communication habits and are increasingly dependent on technology in their daily lives.

In previous studies, the contextual factors – such as mentors' negative views about the use of mobile technology by nursing students in the clinical practice (McNally et al. 2017) and similar negative views held by nurse teachers in educational institutions (Doyle et al. 2014) – have been reported as complicating the full use of mobile technology during the clinical practicum. In this study, no resistance to the use of the MCI or mobile device use in the practicum wards by students was met, although it has been reported in previous studies (e.g.Martyn et al. 2014, Beauregard et al. 2017). However, some negative attitudes towards the MCI and the use of mobile technology were perceived by the researcher at the study UAS. Nonetheless, at the time of the MCI implementation, the general infrastructure situation of many UAS in Finland, including the study UAS, did not support the use of mobile technology in nursing education. Therefore, to enhance nursing education through the use of new mobile technology, nurse teachers require access to adequate mobile technology. Furthermore, the nursing curricula needs to be developed in line with the ongoing digitalisation in society and in accordance with international and national recommendations (EC 2014, Junger 2016, Parviainen et al. 2017). Thus, further rigorous research is needed to produce evidence of the ability of mobile technology use to improve clinical learning by students. The nurse teachers' and mentors' attitudes towards mobile technology as well as their technology literacy needs also require research, so that the full use of mobile technology in nursing education can be maintained and ensured.

This study demonstrated that nursing students used the App both at home and during clinical shifts (Phase III). This is an interesting finding, since previous studies reveal that nursing students avoid using mobile devices in practicum wards due to a negative ward culture against mobile devices (e.g. Martyn et al. 2014). The finding could be a result of the general cultural attitude towards mobile technology in Finnish society – one of the most advanced digital economies in the EU (EC 2017b) – as it may be more positive than in the other countries where the prior studies have been conducted. Furthermore, the implementation of the MCI may have changed the attitudes of the staff members on the clinical practicum wards (Moore et al. 2015). One possible explanation might be the fact that the nursing staff, especially mentors have reported limited nurse teacher support and a lack of competence in student supervision in previous studies (Helminen et al. 2014, 2016, 2017). Thus, this new alternative cooperation method might be seen as a possibility for improving the situation.

This study (Phase I, III) provides an important evidence base for the further development of the App and the whole MCI. Based on the study findings, the App seems to meet the students' needs for having an easy-to-use and ubiquitous hands-on cooperation method for student–teacher cooperation during the clinical practicum. Nevertheless, based on student feedback, the App requires further development and the designing of additional features.

7.2   Validity and reliability of the study

The strength of this study lies in the use of various methods and perspectives to develop the App and the MCI as well as to evaluate the effectiveness and acceptability of the MCI. The validity and reliability of this study were considered throughout all study phases (Phases I–III). The study Phases I and II enabled a valid and reliable basis for Phase III which contained the intervention implementation and the evaluation of the effectiveness and acceptability of the MCI in authentic clinical learning environments. In the following chapters the validity and reliability of the data collection, instruments, intervention and results are discussed.

7.2.1 *Validity and reliability of the data collection*

The researcher conducted all data collection in Phases I–III by herself or in cooperation with another researcher to ensure the reliability of the data collection.

In Phase I and Summary, the integrative review method, according to the criteria of Whittemore and Knafl (2005), was chosen for investigating and appraising studies with diverse methodological strategies. Four scientific databases were selected for the review: PubMed/Medline, CINAHL, PsycINFO and ERIC, which are essential and comprehensive sources for identifying previous studies in the field of nursing education research. Moreover, the database searches were complemented by manual searches of the reference lists of the articles. Since MeSH terms were not available regarding mobile technology, the search terms were carefully determined by two researchers in cooperation with an information specialist. The comprehensive search term list is described in Chapter 3.3, Table 3 and in Paper I. The comprehensive documentation of the literature search process is described in Paper I (Paper I, Figure 1).

However, there were also limitations regarding the literature search. The general web search engines such as, Google and Google Scholar, were excluded from the literature search, which may have caused publication bias (Whittemore & Knafl 2005). The web search engines might also have identified the grey area of the topic of interest that is, proceedings and other unpublished up-to-date knowledge about recent mobile technology innovations and solutions in the area of interest. To enhance rigor and validity, the data evaluation and data analysis of the integrative review were conducted by two researchers independently of each other but following a consensus discussion. The conclusion of the review is carefully documented in Paper I (Paper I, Figure 2) (Whittemore & Knafl 2005).

In Phase II, the data for evaluating the content validity of the developed T_2 - subscale of the CLES+T_2 scale were collected by the researcher herself via two rounds of expert panels with questionnaires including comprehensive instructions about the item level and subscale level evaluations. The participants – teachers, nursing education researchers, CLES+T experts and second-year pre-registration nursing students – were purposively chosen to strengthen the reliability of the data collection. The data for the pilot study of the MCI were collected through researcher observations and the experiences witnessed during the student recruitment and App training sessions as well as face-to-face meetings with the nursing students via paper-based structured questionnaires. The drop-out rate was 3 and the overall response rate was 100% in the pilot study (Paper II).

In Phase III, statistical power was ensured by estimating the sample size. The sample size was estimated by using the greatest standard deviation (Lamb & Altman, 2015) for the data collected from the graduating nursing students by Kajander-Unkuri et al. (2014) by using the NCS (Meretoja et al. 2004a) as the primary outcome (Jull & Aye 2015) of the RCT. The data were collected by the researcher herself in the study hospitals to decrease the risk of missing data and

dropouts. Moreover, the data were collected via paper-based questionnaires – to avoid the risk of high attrition rates posed by electronic data collection (Cantrell & Lupinacci 2007). The data were collected in hospital settings – at three time points: at the baseline and at the end of the MCI, including one data collection before the final evaluation discussion (T1) and one after it (T2). Nursing students and mentors completed the NCS by themselves before the final evaluation of the clinical practicum was made, so as to obtain as subjective experience of the nursing students' competence as possible. A systematic and researcher-informed data collection was used to minimise the drop-out rate of students and mentors. The drop-out rate of the students was 1 and the overall response rate was 99% (n=101), whereas the mentors' overall response rate was 93% (n=95).

The limitations of this study include the use of student self-assessment for the outcomes of the MCI. Student self-assessment may have led to the overestimation of the outcomes (Kajander-Unkuri et al. 2016). However, the data collection for the primary outcome using the NCS was performed by a combination of student self-assessments and mentor assessments to provide rich and valid data with which to evaluate the effectiveness of the mobile cooperation intervention. Moreover, the NCS has undergone validity and reliability testing and has produced consistency in results across different population groups and settings (Flinkman et al. 2017).

7.2.2 Validity and reliability of the instruments

In Phase I, a critical appraisal of the studies was performed by two independent researchers through consensus discussions. First, a critical appraisal of the included studies was performed using standardised study design-specific checklists comprising the CONSORT 2010 Statement with a 25-item checklist (Moher et al. 2012), the STROBE Statement with a 22-item checklist (von Elm et al. 2007) and the TREND Statement with a 22-item checklist (Des Jarlais et al. 2004). This ensured that the critical appraisal tools were appropriate for the type of study and that the entire appraisal was completed objectively.

In phase II, the CLES+T scale (Saarikoski et al. 2008) was further developed for this study to accurately measure the nurse teacher's pedagogical cooperation with the students. The expert panel rounds and the assessment of the item level and subscale level content validity indexes following the criteria by Lynn (1986) are reported in the published research protocol (Paper II). This new CLES+T_2 scale was used for the first time in this study. The new T_2-subscale demonstrated an appropriate level of content validity (Phase II) and good internal consistency (Phase III) for measuring the quality of the nurse teacher's pedagogical cooperation with students as experienced by the nursing students. The item-level

CVI ranges from 0.88 to 1.0, while the CVI at the subscale level was 0.90. The CLES+T$_2$ scale was developed in Finland but its use cannot be considered until there is further rigorous testing of its construct validity using explorative factor analysis with an adequate sample size, which was not possible to attain in the frame of this study. The SECP instrument (Cheraghi et al. 2009) was double-translated for this study, from the English version into Finnish using the back-translation method (Sousa & Rojjanasnirat 2011). In addition, one nursing student from the UAS who spoke Persian as her mother tongue, revised the congruence between the Finnish translation of the SECP instrument and the original Persian version of the instrument by checking the correspondence of the contents of the items of the Finnish translation with the original Persian version.

In Phase III, the instruments were carefully selected to measure the primary and secondary outcomes of the MCI. All the selected outcome measures were used in previous studies using student samples and were found to have good internal validity. The primary outcome measure, the NCS, is the most widely used instrument internationally for assessing nurses' generic competence and allowing comparisons of competence across a variety of settings (Flinkman et al. 2017). In addition, the NCS has previously been considered a sufficiently valid instrument for use with nursing student samples in Finland (Kajander-Unkuri et al. 2014, 2015, 2016). While this was the first time the NCS was used for nursing students in the early stage of the nursing degree studies, the criterion validity of the NCS had been estimated, and showed that the NCS had a significant moderate positive correlation with both of the secondary outcomes at the baseline and at the end of the MCI (all r>0.35, all *p*<0.002). The internal consistency was at an acceptable level at the end of the MCI – the Cronbach's alpha value was 0.96 (Paper III).

The one secondary outcome measure, the SECP instrument (Cheraghi et al. 2008), was developed in Iran and based on the internationally used nursing process framework to measure student self-assessment of their ability to cope in a clinical performance. In a previous study with a student sample, the instrument showed good psychometric properties (Cheraghi et al. 2009). However, the rigorous testing of construct validity using the explorative factor analysis and an adequate sample size is required. The internal consistency was acceptable at the end of the MCI; the Cronbach's alpha value was 0.98 (Paper III).

The other secondary outcome measure, the CLES+T scale, is the most translated and validated of instruments that measure the quality of a clinical learning environment in nursing education (Mansutti et al. 2017). The validation of the CLES+T scale and its psychometric properties has been conducted both in Finland (Saarikoski & Leino-Kilpi 2002, Saarikoski et al. 2008) and internationally, e.g. in Sweden (Johansson et al. 2010, Bos et al. 2012, Gustafsson et al. 2015b), Norway

(Henriksen et al. 2012), Italy (Tomietto et al. 2012), Germany (Bergjan & Hertel 2013), New Zealand (Watson et al. 2014), Cyprus (Papastavrou et al. 2016a), Croatia (Lovrić et al. 2016), Spain (Vizcaya-Moreno et al. 2015), South Korea (Kim et al. 2018) and Austria (Mueller et al. 2018). The internal consistency of the further developed CLES+T$_2$ scale was acceptable at the end of the MCI with a Cronbach's alpha value of 0.93 (Paper III, Table 4).

The process evaluation measure included questions developed for this study and the SUS. The first part of the process evaluation questionnaire (Peq) assessing the students' commitment to and experiences of the MCI was developed for this study based on the integrative review in Phase I and was used in this study for the first time. The questionnaire was pilot tested by bachelor's level nursing students (n=6), nurse teachers (n=2), a nursing education researcher (n=1), mentors (n=1) and a head nurse (n=1) at Phase II of this study. The second part of the Peq included the SUS (Brooke 1996, 2013) which is widely used (Martins et al. 2015) and is stated to be adequate for measuring the general usability (Brooke 1996, 2013) of a wide range of products and user interfaces (Bangor et al. 2008, Sauro 2011, Martins et al. 2015). The scale has been demonstrated to be valid (Sauro 2011, Brooke 2013, Martins et al. 2015) and reliable (Sauro 2011, Brooke 2013). The internal consistency of the SUS was acceptable at the end of the MCI due to a Cronbach's alpha value of 0.89.

7.2.3 Validity and reliability of the intervention

The strength of this study lies in its robust RCT design, representing a gold standard in the evaluation of the effectiveness of interventions (von Essen 2015, Clark et al. 2018). In Phase II, in the construction of the study protocol (Paper II), the SPIRIT 2013 Statement (Chan et al. 2013) was followed to guarantee the high quality of the study protocol and to promote the proper implementation and reporting of the MCI (Borglin & Richards 2010, Chan et al. 2013, Lamb & Altman 2015). An attempt was made to improve the quality of the protocol by following the SPIRIT 2013 Statement (Chan et al. 2013) in conjunction with the TIDieR checklist (Hoffmann et al. 2014) for the intervention description, so as to allow the future replication of the MCI. Thus, the second strength of this study lies in its strictly followed rigorous and high-quality study protocol that avoids performance bias (Borglin & Richards 2010). However, the participants in this study could not be blinded because of the pragmatic design of the RCT (Lamb & Altman, 2015), which may have resulted in bias in the results.

The intervention was conducted by one nurse teacher and the students' individual mentors. The mentors were trained in the use of the App and intervention procedures by one-to-one face-to-face training sessions or by phone calls with the researcher herself during the first week of the intervention. According to the baseline measures, the student study groups (IG and CG) were comparable and there were no significant differences in the socio-demographics between the groups (Paper III, Table 1). Moreover, the mentor study groups were comparable and had no significant differences in the socio-demographics between the groups (Appendix 2). The control to ensure similar level quality in the learning environments was determined (Jull & Aye 2015) by the register data collected from the original CLES+T scale in 2014 regarding the seven study hospitals at the baseline. Nevertheless, the implementation of RCT in educational settings is complex and challenging, making control of confounding variables difficult (Clark et al. 2018). Thus, confounding variables in the clinical learning environment are possible but for all participants in both groups. Both groups received the same standard content in cooperation with the same teacher and the mentors supervised the students in both groups using standard procedures. In addition, it was not possible to randomize the wards in the study hospitals due to the nursing students' rights to reserve and change the practicum ward until the beginning of the practicum period. Thus, participant contamination may have occurred due to the interactions between students in the IG and CG at the same practicum ward.

Nevertheless, one strength of this study lies in the mixed methods process evaluation, which so far has been scarcely reported in nursing education research. The process evaluation was conducted among nursing students in the intervention group to explore the acceptability of the mobile cooperation intervention and to support the post-hoc interpretation of the results (Craig et al. 2013, Moore et al. 2015). The process evaluation included the collection of both the quantitative and qualitative evaluation data. During the MCI, the researcher collected the reasons given for why students dropped out by making phone calls or by sending emails to them and asking why they chose not to participate any further in the study. The students' commitment to and experiences of the MCI were evaluated at the end of the MCI, after the final evaluation of the clinical practicum (T2) via a process evaluation questionnaire (Peg) developed for this study. After the intervention, semi-structured focus group interviews (T3) and essays (T4) (Figure 6, Page 60) were conducted at the study UAS to obtain information about the students' MCI experiences.

7.2.4   *Validity and reliability of the results*

In Phase I, the critical appraisal of the previous studies focusing on the use of mobile devices in nursing student–nurse teacher cooperation during the clinical practicum revealed weaknesses in study designs, samples, instruments and results (Paper I, Appendix 1). Thus, the relevance of the findings of the review must be carefully considered as it is difficult to draw firm conclusions from previous studies.

In Phase II, the construction of the high-quality study protocol (Paper II), which followed the SPIRIT 2013 Statement (Chan et al. 2013) in conjunction with the TIDieR checklist (Hoffmann et al. 2014), promoted the proper implementation and reporting of the outcomes of the MCI (Borglin & Richards 2010, Chan et al. 2013, Lamb & Altman 2015).

In Phase III, the nursing students' (Paper III, Table 1) and mentors' (Appendix 2) study groups were compared. There were no significant differences in the demographic characteristics between the study groups (IG and CG). To ensure comparable study groups, the nursing students were recruited from one UAS, during the same study term of nursing students beginning an internal medicine or surgical clinical practicum in one of the study hospitals. Participant contamination between the groups by means of passing information and thus altering the results at the ward level is quite possible; however, this limitation could be controlled for by randomization on the ward level but it was not possible in this study.

Data analyses were performed on an intention-to-treat approach to prevent attrition bias (Borglin & Richards 2010). In addition, the statistician was blind regarding the group allocation in order to prevent the bias in the results. The results are reported in compliance with the CONSORT 2010 Statement (Moher et al. 2012) in conjunction with the TIDieR checklist (Hoffmann et al. 2014). The process evaluation report of this study was written after analysing the outcomes of the intervention, thus there is risk that the qualitative process evaluation data was interpreted in the light of intervention outcomes (Moore et al. 2015).

The data were collected from second-year nursing students from one UAS, covering only about 3% of the national second-year bachelor's degree students in the nursing, midwife and public health population in 2015 (Ministry of Education and Culture 2017a, 2017b). The results are not generalisable to the whole bachelor's degree level nursing student population. However, they do provide rigorous evidence to be considered in the development of nursing curricula for bachelor's degree level nursing education both nationally and internationally.

7.3 Suggestions for future research

In this chapter, the suggestions for future research are described from the methodological perspective as well as the nursing education and intervention development viewpoints. There is a clear need for nursing education research – in the context of the clinical practicum for nursing students (Hentinen 1989, Saarikoski 2002, Suikkala 2007, Brunou 2009, Luojus 2011, Jokelainen 2013, Kajander-Unkkuri 2016, Helminen 2017, Mikkonen 2017) – especially to produce rigorous evidence that can be used to facilitate nursing student–nurse teacher cooperation and to improve the nursing students' clinical learning outcomes and consequently the outcomes of patient care.

The suggestions for future research are as follows:

o This study produces a new evidence base of the effectiveness and acceptability of a mobile cooperation intervention in the context of a clinical practicum, which represents the essential component of nursing education. There is a need for further studies to strengthen the evidence base of the nursing student–nurse teacher mobile cooperation during the clinical practicum.

o In this study, only a limited number of outcomes for evaluating the effectiveness of the MCI could be analysed. It is essential to evaluate its cost-effectiveness in future studies to support the political and UAS level decision making concerning mobile technology use in the nursing student–nurse teacher cooperation.

o There is need to pay attention to the nursing students' competence development during the clinical practicum throughout their nursing degree studies. Thus, longitudinal research with a longer intervention duration should be implemented. This is possible only with longer clinical practicum periods or with several intervention implementations throughout the nursing students' degree studies.

o It is worth further developing the content of the novel MCI developed and tested for the first time in this study in order to more effectively support the clinical learning outcomes of students and allow them to respond to the competence and self-efficacy demands of the complex clinical environments facing future RNs.

o The CLES+T$_2$ scale needs to be tested further. In particular, the construct of the scale should be analysed to see how the additional 5 new items, measuring the pedagogical cooperation of the nurse teacher, fit with the

whole scale. Moreover, specific sensitive testing approaches should be used.

o The nurse teachers' and mentors' experiences and competences regarding mobile technology use during the clinical practicum should be examined so as to obtain evidence of the usability and acceptability of mobile technology use in mentors' and nurse teachers' supervision procedures that the full use of mobile technology in nursing education can be maintained and ensured.

o Ethical issues that arose due to the evolving use of the mobile technology during the clinical practicum need attention in nursing education and must be examined in the future.

7.4 Practical implications of the study

According to the results of this study the following practical implications for nursing education, nursing practice and policy making can be presented.

o The mobile cooperation intervention is a potential alternative to existing nursing student–nurse teacher cooperation methods. The mobile cooperation intervention seems to be significantly effective at facilitating the nursing student–nurse teacher cooperation during the clinical practicum and for strengthening the nurse teacher's role in supporting nursing students during the challenges faced in the clinical practicum.

o The integration of mobile technology into nursing education has to be carefully considered. The integration of mobile technology with nursing student–nurse teacher cooperation does not seem to significantly improve nursing students' competence, self-efficacy and the quality of the clinical learning environment. If these clinical learning outcomes are to be improved more effectively, there is need to develop and examine new pedagogical activities for the nurse teacher and new practicum procedures should be added to the App so that they can be conducted in the mobile cooperation intervention.

o Both nursing students and mentors need support in assessing nursing student competence. The assessment of nursing student competence is an integral part of the degree studies, especially in the clinical practicum when assessing the nursing students' fitness for nursing practice. This has to be considered seriously when planning nursing curricula, the implementation

of the clinical role of the nurse teacher and the further education of the mentors.

o The results of this study have implications for the pre-practicum theoretical training conducted in educational institutions. To maintain the nursing students' pre-practicum theoretical knowledge at an adequate level, the quality of the clinical learning environment they experience and their self-efficacy development during the clinical practicum could be improved. This may also have long-term effects on the availability of the nursing workforce for clinical practice.

o The mobile application developed in this study may provide new ways of documenting the nursing students' learning throughout their nursing degree studies. In addition, it could also help nurse teacher and nurse mentor activities when they supervise nursing students during a clinical practicum. This information can be used to improve the quality of nursing education.

o The novel mobile cooperation intervention was highly valued and accepted by nursing students – the end-users of the mobile application. Moreover, the commitment of the mentors as intervention providers seemed to be high, revealing that the implementation of the mobile cooperation intervention is also possible in busy practicum wards. However, that issue was not examined in this study and needs further research.

8   CONCLUSIONS

The cooperation between nursing student and nurse teacher is a complex and challenging supervision relationship and complex clinical practice raises concerns about adequate and effective support for nursing students during the clinical practicum. The nursing education reforms have brought about remarkable changes in the nursing student–nurse teacher cooperation methods. Moreover, society's technological development will have an impact on this cooperation in the future as well. Nevertheless, there is no single superior method for the nursing student–nurse teacher cooperation and consequently there are variations in its implementation both nationally in Finland and internationally. This cooperation has been studied alongside educational reforms in Europe, but it has remained a challenging phenomenon with regard to the provision of support for the clinical learning of the nursing students. The significance of the availability of nurse teacher support for nursing students during the practicum is evident and thus supporting students during their clinical practicum is emphasised. Nursing education should examine the ever increasing evidence for the use of mobile technology in nursing education when seeking to deliver and maintain effectiveness and quality, thus generating workforces with sufficient competence and appropriate self-efficacy to provide safe, high-quality, people-centred, accessible and affordable care to patients.

The mobile cooperation intervention (MCI) showed significant effect on improving the experienced quality of the nurse teacher's clinical role, especially regarding cooperation. This was detected with significant group-differences in favour of the intervention group that used the App to cooperate with the nurse teacher during the clinical practicum. The results of this study are educationally significant in demonstrating that the MCI is equally effective as standard cooperation via email communication and paper-based documentation – when the self-assessed competence, self-efficacy and quality of the CLE are considered.

Participation commitment in the MCI was high, although there were minor challenges with some participant's technology literacy and Wi-Fi connectivity in the study hospitals. The App was experienced as easy to learn and use by the nursing students. Nursing students using the App experienced feelings of connectivity, that the nurse teacher was available for them and that they could achieve their aims. This study has the potential to influence future development of nursing student–nurse teacher cooperation methods by providing rigorous evidence and stimulus for nursing education. Moreover, this study answers the current need for a robust evidence base to guide educational and policy decision-making when integrating mobile technology into nursing education.

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APPENDICES

Appendix 1. Critical appraisal by designing specific checklists of the studies included in Phase I.

CONSORT 2010	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Total score
Kenny et al. (2009)	-	+	-	+/-	+	+	-	-	-	+/-	-	-	-	+	+	+	+	-	-	-	-	+	-	-	-	8/25

CONSORT 2010 items: (1) Title and abstract, (2) Background and objectives, (3) Trial design, (4) Participants, (5) Interventions, (6) Outcomes, (7) Sample size, (8) Sequence generation, (9) Allocation, (10) Implementation, (11) Blinding, (12) Statistical methods, (13) Participant flow, (14) Recruitment, (15) Baseline data, (16) Numbers analyzed, (17) Outcomes and estimation, (18) Ancillary analyses, (19) Harms, (20) Limitations, (21) Generalisability, (22) Interpretation, (23) Registration, (24) Protocol, (25) Funding Moher et al. 2012).

STROBE Statement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total score
Kenny et al. (2012)	+/-	+	+	+	-	+	+	+	-	-	+	+/-	+/-	+	+	+	+	-	-	+	+	-	12.5/22

STROBE items: (1) Title and abstract, (2) Background/rationale, (3) Objectives, (4) Study design, (5) Setting, (6) Participants, (7) Variables, (8) data sources/measurement, (9) Bias, (10) Study size, (11) Qualitative variables, (12) Statistical methods, (13) Participants, (14) Descriptive data, (15) Outcome data, (16) Main results, (17) Other analyses, (18) Key results, (19) Limitations, (20) Interpretation, (21) Generalisability, (22) Funding (von Elm et al. 2007).

TREND Statement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total score
Wu (2014)	+/-	+/-	+/-	+	+/-	+	-	-	-	-	+/-	-	-	-	-	+/-	+/-	-	+/-	+/-	-	+/-	7/22
Martyn et al. (2014)	+/-	+	+/-	-	+/-	+	+	-	-	-	+/-	-	-	-	-	-	-	-	-	+/-	-	+	6.5/22
Wu and Sung (2014)	+/-	+/-	+/-	+	+/-	+	-	-	-	-	+/-	+/-	-	-	-	+	+/-	-	+/-	+/-	-	-	7.5/22
Wyatt et al. (2010)	+/-	+	+/-	+/-	+/-	-	-	-	-	+/-	+/-	-	-	+/-	-	+/-	+/-	-	-	+	-	-	6.5 /22
Young et al. (2010)	+	+/-	+/-	+/-	+/-	-	-	-	-	+/-	+/-	+/-	-	-	-	+/-	+/-	-	+	+/-	-	-	5.5/22
Bogossian et al. (2009)	+/-	+/-	+/-	+/-	-	-	-	-	-	+/-	-	+/-	-	+/-	-	+/-	+/-	-	+/-	+/-	-	-	5/22
Mackay and Harding (2009)	+/-	+/-	+/-	+/-	+/-	-	-	-	-	+/-	-	+/-	-	-	-	+/-	+/-	-	-	+/-	+/-	-	6.5/22
Wu and Lai (2009)	+/-	+/-	+/-	+/-	+/-	-	-	-	-	+/-	-	+/-	-	-	-	+/-	+/-	-	+/-	+/-	-	+/-	5.5 /22
Garrett and Jackson (2006)	+/-	+	+/-	+/-	+/-	-	-	-	-	+/-	-	-	-	-	-	-	+/-	-	+/-	+/-	-	+	5.5/22

TREND items: (1) Title and abstract, (2) Background (3) Participants, (4) Interventions, (5) Objectives, (6) Outcomes, (7) Sample size, (8) Assignment method, (9) Blinding (masking), (10) Unit of analysis, (11) Statistical methods, (12) Participant flow, (13) Recruitment, (14) Baseline data, (15) Baseline equivalence, (16) Number analyzed, (17) Outcomes and estimation, (18) Ancillary analyses, (19) Adverse events, (20) Interpretation, (21) Generalizability,(22) Overall evidence (Des Jarlais et al., 2004).

+ = adequate description, +/- = inadequate description, - = no description at all.

Appendix 2. Demographic characteristics of the mentors at T1.

	IG (n=49)	CG (n=46)	*p* Group
Age			0.212
Years, *median (range)*	36.0 (23.0–59.0)	37.0 (23.0–64.0)	
Gender			0.484
Female, *n (%)*	49 (100.0)	45 (97.8)	
Male, *n (%)*	3 (5.8)	1 (2.2)	
Professional qualification			
Registered nurse, *n (%)*	45 (91.8)	40 (87.0)	0.865
Public health nurse, *n (%)*	1 (2.0)	1 (2.2)	
Midwife, *n (%)*	1 (2.0)	2 (4.3)	
RN and public health nurse, *n (%)*	2 (4.1)	3 (6.5)	
Working experience			
In social and healthcare, months, *median (range)*	120.0 (18.0–418.0)	144.0 (3.0–516.0)	0.410
In the current unit, months, *median (range)*	72.0 (8.0–358.0)	73.5 (3.0–504.0)	0.505
Mentoring experience			
As a mentor, month, *median (range)*	85.0 (0.0–360.0)	72 (3.0–504.0)	0.835
As a key mentor, month, *median (range)*	54.0 (6.0–120.0)	48 (0.0–351.0)	0.719
Students mentored during last year, *median (range)*	3.0 (0.0–8.0)	3.0 (1.0–10.0)	0.564
Current position as a key mentor			
Yes, *n (%)*	17 (34.7)	12 (26.1)	0.383
No, *n (%)*	32 (65.3)	34 (73.9)	
Own initiative to mentoring			
Yes, *n (%)*	20 (40.8)	12 (26.7)	0.192
No, *n (%)*	29 (59.2)	33 (71.7)	
Own attitude to mentoring			
Like it a lot, *n (%)*	11 (22.4)	9 (19.6)	0.989
Like it quite a lot, *n (%)*	28 (57.1)	27 (58.7)	
Neutral, *n (%)*	9 (18.4)	9 (19.6)	
Like it quite little, *n (%)*	1 (2.0)	1 (2.2)	
Like it very little, *n (%)*	0 (0.0)	0 (0.0)	
Mentoring resources			
Yes, enough, *n (%)*	27 (55.1)	19 (41.3)	0.220
No, not enough, *n (%)*	22 (44.9)	27 (58.7)	
Further education opportunity in mentoring			
Yes, *n (%)*	23 (36.9)	19 (41.3)	0.677
No, *n (%)*	9 (18.4)	7 (15.2)	
Neutral, *n (%)*	17 (34.7)	20 (43.5)	
Further education in mentoring			
Educational days in hospital district, *n (%)*	17 (34.7)	12 (26.1)	0.383
Education by UAS, *n (%)*	15 (30.6)	12 (26.1)	0.656
Mentor meetings in hospital district	16 (32.7)	10 (21.7)	0.258
Professional literature, *n (%)*	18 (36.7)	16 (34.8)	1.000
Other way, *n (%)*	10 (20.4)	11 (23.9)	0.806
No further education, *n (%)*	11 (22.4)	13 (28.3)	0.638
Perception of own mentoring skills			
Very adequate, *n (%)*	3 (6.1)	4 (8.7)	0.161
Adequate, *n (%)*	37 (75.5)	26 (56.5)	
Neutral, *n (%)*	8 (16.3)	15 (32.6)	
Inadequate, *n (%)*	0 (0.0)	1 (2.2)	
Very inadequate, *n (%)*	0 (0.0)	0 (0.0)	

Consideration of choice of career			
Yes, *n (%)*	20.4 (10)	15.2 (7)	0.572
No, *n (%)*	67.3 (33)	78.3 (36)	
Neutral, *n (%)*	10.2 (5)	6.5 (3)	
Students' theoretical knowledge before clinical practicum			
Very adequate, *n (%)*	1 (2.0)	1 (2.2)	0.894
Adequate, *n (%)*	15 (30.6)	18 (39.1)	
Neutral, *n (%)*	26 (53.1)	20 (43.5)	
Inadequate, *n (%)*	5 (10.2)	6 (13.0)	
Very inadequate, *n (%)*	1 (2.0)	1 (2.2)	
Students' practical skills before clinical practicum			
Very adequate, *n (%)*	0 (0.0)	1 (2.2)	0.607
Adequate, *n (%)*	17 (34.7)	11 (23.9)	
Neutral, *n (%)*	20 (40.8)	23 (50.0)	
Inadequate, *n (%)*	8 (16.3)	9 (19.6)	
Very inadequate, *n (%)*	3 (6.1)	2 (4.3)	

Appendix 3. Nurse teachers' pedagogical cooperation with students (CLES+T$_2$).

Items	IG (n=52)		CG (n=48)		
	Median	Q$_1$, Q$_3$	Median	Q$_1$, Q$_3$	*p* Group
It was easy to cooperate with the nurse teacher	10.00	8.30, 10.00	9.00	8.00, 10.0	0.19
Nurse teacher responded quickly to my requests for cooperation	9.00	8.00, 10.00	9.00	9.00, 10.00	0.16
The cooperation with the nurse teacher promoted my learning	9.00	9.00, 10.00	8.00	8.00, 9.30	0.043*
Nurse teacher helped me to relief my stress	8.00	8.00, 9.00	7.00	7.00, 8.50	0.024*
I received individual supervision from the nurse teacher	8.00	7.00, 10.00	9.00	8.00, 9.00	0.13
Overall mean	8.80	7.60, 9.60	7.90	6.30, 9.00	0.026*

Group p-value indicates whether there is a difference between IG and CG.

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